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THE FORTY IMMORTALS—THE FRENCH ACADEMY OF THE INSTITUTE OF FRANCE.

THE FRENCH ACADEMY.

THE Académie Française is the most celebrated of the five academies included in the Institute of France. It owes its origin to Cardinal de Richelieu, who had form, so, on the 2d of January, 1635, the newly formed French Academy received letters patent signed by Louis XIII. The Parliament, jealous of this new power, refused, for two years, to register what was looked upon as a parliament of writers.

the Academy with their usual ill luck, for the entire history of this body is checkered by gross errors in the selection of members—but more of this farther on. Apart from its ordinary dictionary, the Academy has long been at work on a special etymological dictionary

THE FORTY IMMORTALS—THE FRENCH ACADEMY OF THE INSTITUTE OF FRANCE.

conceived the idea of basing the glory of France not only on the power of her arms, but also on the influence of her language and literature. Men of letters had been in the habit of assembling periodically to discuss literary matters. The great minister determined to give to this association a regular and legal

The first task undertaken by the French Academy was to purify and fix the language. This has occupied it more or less throughout its existence, though at the present time the best dictionary of the French language is not the one issued by the French Academy, but the dictionary of M. Littré, who was rejected by

with which, however, it has made little progress. Nor can it be said to have succeeded at any period of its existence in making itself felt as the representative of contemporary French literature.

It consisted from the beginning of forty members elected for life, to each of whom is assigned his seat,

"fauteuil," or arm chair, though this arm chair is purely theoretical, the academicians having always sat on benches. On the death of a member, his "chair" becomes vacant, and the thirty-nine members elect a successor. The filling of the chairs with mediocrities was scored by Voltaire, when he said that the Academy was an assembly of noblemen, prelates, lawyers, men of the world, "and even writers" were admitted. He was himself elected in 1747.

M. Arsène Houssaye has written a book called "The Forty-first Chair," in which he shows that there has always been since the foundation of the Academy some writer of the first eminence for whom, if no other could have been offered to him, a forty-first chair could have been provided. As a rule, men of learning have more chance of being elected to a chair, learning being held of more account than genius. Alexandre Dumas the elder was never asked to join the Academy; and it was understood that if he proposed himself he would not be accepted. Originally, on very rare occasions, the Academy would invite a distinguished writer to join them, but, in consequence of some refusals, notably that of Beranger, it now elects no one who has not, first of all, asked to be received.

M. Guizot once described the style of man peculiarly acceptable as a member of the Academy. "I shall vote for him," said Guizot; "for whatever may be said on the subject, he has the qualities of a true academician; he has a good demeanor, he is very polite, he is decorated, and he has no opinions. I know that he has written a few books, but what of that? A man cannot be perfect." This arraignment coming from an academician is even more severe than the cold facts presented by M. Arsène Houssaye, who gives an interesting list of names of men who would have been the eternal glory of that absent piece of furniture. First on his list comes the great Descartes, from whom dates, in France at least, true liberty of thought; then comes Pascal, author of the famous "Lettres Provinciales;" then follows Molière, La Rochefoucauld, Bayle, LeSage, the author of "Gil Blas;" the Abbé Prévost, author of "Manon Lescaut;" Jean Jacques Rousseau, Diderot, the poet André Chénier, Beaumarchais, Lamennais, and lastly Balzac, the greatest novelist of France, if not of all time. Coming to more recent times, one might suggest the names also of the late Alphonse Daudet, whose splendid works would have adorned the Academy. M. Zola should also be admitted.

According to H. Sutherland Edwards in "Paris, Old and New," the Academy was suppressed at the Revolution, coming to life again as a literary branch of the Institute under the First Empire.

The Academy has considerable funds at its disposal, and it receives 85,000 francs annually from the state. It awards prizes for eloquence, poetry and "virtue," and prizes for the best work of fiction, and "crowns" certain literary productions, as, for example, M. Müntz's "Raphaël." Whatever may have been the sins of omission with which the Academy can be charged, it has always been a dignified body of men, and their power, which is considerable, has not been abused.

We will now take up briefly the various academicians in the order of our engravings, for which we are indebted to Le Monde Moderne.

M. Le Duc Albert de Broglie, born in 1821, was elected in 1862. He is the author of historical works.

M. Victor Cherbuliez, born 1828, elected 1881, is the author of many works of fiction.

M. Jules Lemaitre, born 1853, elected 1895, is known as an author of dramatic criticisms and miscellaneous writings.

M. Gaston Boissier, born 1823, elected 1876, is the perpetual secretary of the Academy. He is well known for his archæological writings, notably his "Promenades Archéologiques."

M. Costa de Beauregard, born 1835, elected 1896, is the author of historical works.

M. Octave Gréard, born 1828, elected 1886, is a writer on educational matters and literary criticism.

M. Albert Sorel, born 1842, elected 1894, is a man of letters who has treated diplomatic and historical questions.

His Eminence Cardinal Perraud, born 1828, elected 1882, has written on the subject of oratory and has also written biographies of ecclesiastics.

M. Edmond Rousse, born 1816, elected 1870, has written some law books.

M. Henry Houssaye, born 1848, elected 1894, has written legal and historical works.

M. Victorien Sardou, born 1831, elected 1877, is the well known dramatic author and critic.

M. Sully Prudhomme, born 1839, elected 1881, is a poet and man of letters.

M. Jules Claretie, born 1840, elected 1888, is one of the best known critics in France.

M. Pierre Loti (Julien Viaud), a lieutenant in the French navy, was born in 1850 and was elected in 1891. He is a novelist and "Madame Chrysanthème" is probably his best known work.

M. Albert Vandal, born 1850, elected 1896, is the last comer in the collection of notables. He has written several works of fiction and some historical works.

M. Le Duc d'Audriffret-Pasquier, born 1823, elected 1878, does not appear to have written anything.

M. Alfred Mézières, born 1826, elected 1874, is the author of critical and biographical works.

M. Le Duc d'Aumale, the fourth son of Louis Philippe, born 1822, elected 1871, died in 1897, after the news of the terrible Bazar de Charité fire in Paris.

M. Emile Ollivier, born 1825, elected 1870, is the author of political works and has written some on the subject of art. He is an authority on ecclesiastical law.

Vicompte Melchior de Vogué, born 1848, elected 1888, is chiefly notable as an author of books of travel.

M. Edouard Pailleron, born 1834, elected 1882, is one of the editors of the Revue des Deux Mondes and has written a considerable number of books.

M. Ludovic Halévy, born 1834, elected 1884, is a charming novelist, being the author of "L'Abbe Constantin."

M. Paul Thureau-Dangin, born 1837, elected 1893, is the author of historical works.

M. Ernest Legouvé, born 1807, elected 1855, is the senior member of the Academy.

M. François Coppée, born 1842, elected 1884, is a well known poet.

M. Le Comte Albert de Mun is well known in French affairs. Is one of the last comers.

M. Edouard Hervé, born 1835, elected 1886, is a writer on historical and educational subjects.

M. J. Bertrand, born 1822, elected 1884, is a scientist, writing on astronomy and mathematics.

M. Charles de Freycinet, born 1828, elected 1890, has written on civil engineering and economic topics.

M. Gaston Paris, born 1839, elected 1896, has written on philological and literary subjects.

M. Le Vicompte Henri de Bornier, born 1825, elected 1893, is the conservateur of the Bibliothèque de l'Arsenal, and is the author of several works.

M. Gabriel Hanotaux comes next in our engraving as a writer.

M. Henri Meilhac, born 1832, elected 1888, is a dramatist and has colloborated with M. Halévy and M. Ph. Gille.

M. Ferdinand Brunetière, born 1849, elected 1893, is a critic of great power. He directs the Revue des Deux Mondes and has also been connected with the Revue Bleue.

M. Paul Bourget, born 1852, elected 1894, is a critic and novelist and is probably best known by "Cosmopolis" and "Outre-Mer."

M. André Theuriet, born 1833, elected 1896, is a dramatic writer and has helped edit the Figaro, L'Illustration, etc.

M. Ernest Lavisse, born 1842, elected 1892, is a historian.

M. Anatole France, born 1844, elected 1896, is a novelist and journalist.

M. José-Maria de Heredia, born in Cuba, 1842, was elected in 1894. He is a poet and journalist.

M. Le Compte d'Haussonville, born 1843, elected 1888, has written sociological, biographical and critical works.

CYCLE PARADE AT CANNSTADT.

EVERY year, at the end of September, the people of Cannstadt hold a festival on the Wasen, an extensive plain on the right bank of the Neckar. It is really a universal Swabian festival, similar to the October festival in Munich, and attracts crowds of people, a large contingent coming from Stuttgart. The procession of flower-trimmed cycles constituted one of the greatest charms of the festival last year, and we publish two engravings (for which we are indebted to the Illustrirte Zeitung) of two of the most noticeable groups that formed part of the display of the Stuttgart Cycle Club, with which the procession was closed. One of these consisted of a baldachin of foliage and flowers supported on four wheels, in which was a bust of King William II. of Würtemberg, and at the feet of the beautiful maiden impersonating the "Goddess of the Art of Cycling" was a little child with a miniature wheel. The other group requires no explanation.

GROUP IN THE PARADE AT CANNSTADT.

TWIN CYCLE IN THE PARADE AT CANNSTADT.

THE DIVINING ROD.*

IT is certainly advisable to inquire into the foundation of all popular beliefs. In some cases popular feeling, or superstition—call it what you will—has undoubtedly led to the discovery of truths not at first understood or accepted by men of science. As, for instance, the danger in the proximity of the barberry plant to crops of corn; a danger well known, though unexplained until the microscope was used to trace out the life-

* "On the So-called Divining Rod, or Virgula Divina: a scientific and historical research as to the existence and practical value of a peculiar human facilty, unrecognized by science, locally known as dowsing." By Prof. W. F. Barrett. (Proc. Soc. Psychical Research, part xxxii, vol. xiii, July, 1897).—From Nature.

history of the minute organism which causes the mischief. On the other hand, careful and unprejudiced inquiry may prove the utter baselessness of some universally accepted belief. We have an instance of this in the statistical inquiry into the connection between the changes of the moon and of the weather. Such a connection is apparently taken for granted by every sailor and farmer; yet a careful analysis of the records shows that the belief is entirely groundless. We are inclined, therefore, to welcome a scientific investigation into the common use of the divining rod for the purpose of finding water or metallic ores.

Turning to the paper of 280 pages which forms the text of this article, we must confess to a feeling of considerable disappointment at the way in which the subject has been treated. What are the points at issue? And what should be the method adopted? Before entering into these questions it may be well to explain in a few words what is the "divining" or "dowsing" about which so much has been written. Here we can recommend Prof. Barrett's paper. He gives a lucid account of the process, clearly distinguishing between the instruments used, which he explains are evidently of no importance whatever, and the physical or mental state of the operator, which is the matter of real moment.

"Divining" or "dowsing" is a method of finding hidden springs or ores by the employment of persons supposed to possess a peculiar faculty not common to mankind in general. This faculty takes the form of a special sensitiveness which causes a forked hazel-twig, or other pointer, held in the hands, to point downward, or upward, when the operator is vertically over the thing sought for. The pointer is a mere "autoscope;" for one dowser used a watch-spring, another a German sausage, and others go with nothing in the hands. The twitching of the rod is, as Prof. Barrett points out, merely an indication of a muscular disturbance, not otherwise very obvious. In the search for water the usual method of divining is for the operator to walk across the ground, rod in hand, stopping at points where involuntary movements cause the rod to turn. At these spots he considers that water is to be found, and he will often go so far as to state the amount that a well sunk there will yield, and the depth at which the spring will be struck. We refer specially to the discovery of water; but the same method is used for the discovery of ores, and sometimes for the tracking of criminals, the feeling responding only, so it is said, to the presence of the particular object for which search is being made.

Two hundred pages of the paper before us are devoted to an "Examination of Evidence," or rather to records of the employment of diviners for the discovery of hidden springs. To this section we will now turn. It is obviously impossible within the limits of this article to analyze the mass of evidence. The difficulty of obtaining trustworthy information as to depth of wells, level of springs, yield of water and other circumstances is very great; even where no personal feeling enters into the question, the details supplied need the most careful sifting. All we can here do is to take some one district, and see how far Prof. Barrett's records correspond with memoranda of our own, made in the course of a geological examination of the same area. Our notes were taken simply for the purpose of obtaining details of the strata, not to prove or disprove any theory.

Two wells are mentioned as sunk in the Isle of Wight under the advice of a diviner, both counting as successes. As to the first, at Arreton, we are only given the diviner's own uncorroborated account, and not knowing the exact site of his well, it is impossible to form an opinion about it. At the other place mentioned, a house called Woodside, at Wootton, near Ryde, two wells had been sunk, under whose advice we know not, in the Oligocene clays, and, of course, they yielded no water. The diviner afterward selected a site a few yards further south, on the edge of the sheet of plateau gravel which supplies water to all the farms and houses over its area. It did not need a diviner to give this advice; any cottager would have given the same, and water was obtained within seven feet of the surface.

These two successes are the only instances mentioned for the Isle of Wight. We, however, can give four others, all of which were failures. Happening to be at Wootton, we came across three other wells being dug under the advice of the diviner—whether the same person as operated at Woodside we do not know. We watched the sinking with great interest, for they were all in strata which a geologist could not advise sinking into, and consequently could seldom examine. Each of the wells was abandoned long before the first water-bearing stratum was reached. In fact, an additional depth of fully two hundred feet would be needed to reach the first spring, and then the supply would be but small and the water bad. A fourth site selected by the diviner was in chalk close to the sea. Some months afterward a geologist was consulted, and he had to advise that nothing but salt water could be obtained there. The fact that a diviner had previously been consulted was only made known to the geologist by an accident. Thus, instead of the Isle of Wight yielding two successes and no failures, it yields four failures, one success—one that did not need a diviner, and one which, on the diviner's testimony alone, counts as a complete success.

This brings us to the principal criticism that we have to make on Prof. Barrett's collection of facts—that he does not give enough weight to the natural tendency of mankind to conceal their failures. A man making a bet or speculation is inclined to boast of it if it is a success. But if it fails, he usually prefers to hold his tongue. It is much the same with divining. It is perfectly natural that both the diviner and his employer should wish to keep the failure secret.

Though the bulk of the paper is taken up with hearsay evidence, we are given two fairly satisfactory test cases, which should be noted by any one who, on the strength of the numerous reports, is inclined to employ a diviner. One of the cases we allude to is the careful trial made in the adits at Richmond Waterworks, in Surrey. Two diviners were employed independently to locate the springs; with the result that they did not agree, and that when borings were made at the spots indicated, most of them were failures. In another case, Prof. Barrett himself tested the powers of a diviner, who was said to have been highly successful elsewhere in finding both water and ores. In Prof. Barrett's hands he failed completely, though an expert thought-reader might have had fair success. The diviner in this case seems to have been accompanied by persons having a complete knowledge of the position of all the springs, wells, and pipes which the dowser failed to find.

If scientific men still think it worth while to spend time on this investigation, we would suggest certain precautions which must be taken before any results can be accepted. Hearsay evidence, like the bulk of that brought forward, is valueless. When the skill of the dowser is tested, it must be at a place where surface indications will not help. Before boring or sinking, the dowser's report must be put into writing, and no additions to his prophecy should afterward be accepted. The operator should not be accompanied by any one who knows the position of the springs or pipes which he is set to find. His companion should be a stranger who can note the exact spots chosen, and write down at the time the exact nature of the diviner's forecast. The depth to the spring, amount of water expected, and continuous or temporary yield should all be noted. It should be carefully recorded whether the diviner predicts an open fissure, which can be tapped by boring, or advises a sunk well to collect a percolating supply. This last precaution is a very necessary one, for it constantly happens that a small boring, with an area of perhaps ten square inches, misses a fissure, or penetrates it at a spot where the walls come together. On the other hand, a sunk well would have a superficial area of some 4,000 square inches, and consequently have a far better chance of obtaining water.

One of the most satisfactory tests would be to set the diviner to map out in some clay district the intricate network of water pipes and drains of an unknown town. Or, if he prefers still water, to hide a number of bottles, some full and some empty, under a cloth or board, and let the dowser select the full ones without touching or seeing any of them. After shifting the bottles a few times this ought to give a sufficiently large number of tests to enable the precentage of failures to be calculated. But here again there must be no one in the room who knows the position of the bottles.

In conclusion, we must express our opinion that this investigation, undertaken at the request of the Council of the Society for Psychical Research, leaves the question in the same state as it found it. We feel that the accumulation of second-hand evidence is of little use, and that what is wanted is a few careful tests by perfectly qualified and unbiased observers. The Richmond inquiry was good, but the failure is explained away by the statement that the dowsers employed were not in the first rank, and were young and inexperienced. Unfortunately all the most successful prophets seem to be dead.

A PHOTOGRAPHIC IMPACT TESTING MACHINE FOR MEASURING THE VARYING INTENSITY OF AN IMPULSIVE FORCE.*

By B. W. DUNN, Lieut. Ordnance Department, U. S. Army.

INTRODUCTION.

THE usual classification of variable forces as impulsive and non-impulsive depends upon their rates of change of intensity.

As ordinarily understood, an impulsive force is one whose intensity changes too rapidly to permit successive measures of it. The main object of all engineering and structural work may be said to be the supplying of adequate resistances to neutralize dangerous forces, and as this cannot be done satisfactorily until the maximum values of these forces are known, it is thought that no apology is necessary for any proposition that promises to advance, be it ever so slightly, our capacity to measure forces.

There are two methods for such measurement, the static and the dynamic methods. The former, which is quite limited in its application, consists essentially in balancing the unknown force by a known one. The latter, which is the true scientific method, requires the accurate measurement of extremely minute intervals of time and space.

The practical measurement of forces has shown but a few applications of the dynamic method, since no apparatus possessing the required delicacy and accuracy has been available. As a direct consequence of our inability to measure impulsive forces, they are found by engineers to be the most dangerous, and our constructions are liable to show unnecessarily high factors of safety and waste of material on the one hand or breakdowns, with their disastrous consequences, on the other. The forces developed by blows furnish the most striking examples of impulsive forces. The engineer is compelled to measure a blow in units of work, although he knows that the ability of his structure to stand the blow depends upon the maximum intensity of the stress developed. In exceptionally favorable cases he may be able to measure the mean stress, but this is of comparatively little use to him.

This necessity for passing from units of intensity to

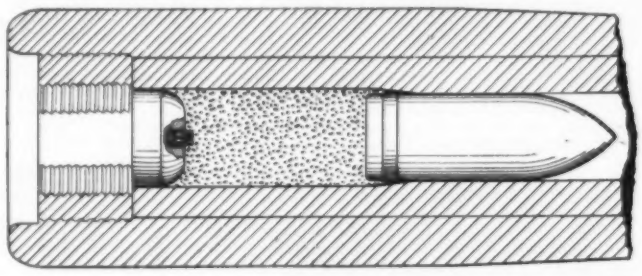


FIG. 1.

units of work in measuring a blow has produced a great deal of confusion. It has caused the average mechanic, and even the average engineer, to think and to speak inaccurately on the subject of blows. How frequently do we hear, in discussions of applied forces, the expression, "Ah! but there we have no longer a pressure, it is a blow!" The speaker evidently thinks that a wide gulf separates a blow from a pressure. He can understand a pressure and anticipate its effect; but the mere fact that a blow is delivered is sufficient, in his mind, to account for any observed effect, and to remove the matter at once from the field of accurate scientific discussion. This popular misconception should be removed. There is no difference between a blow and an equivalent pressure except in the matter of time. The blow produces its maximum pressure in an inconceivably short interval of time, and the static testing machine cannot tell us what that maximum was. We know that the slightest variation in conditions of blow may affect largely the maximum pressure developed, and that this pressure is especially susceptible to differences in duration of blow.

When required to neutralize the effect of an impulsive force the engineer should have information on two points, viz.:

(1) He should know the maximum intensity of the force.

(2) He should know the physical qualities of resisting material when subjected to impulsive forces.

It is a mistake to assume that a piece of metal, or other material, will show the same effect when subjected, on the one hand, to a given force applied slowly—as in a static testing machine—and, on the other, to the same force applied and withdrawn within thousandths or tens of thousandths of a second.

Is it possible to construct a practicable impact testing machine capable of furnishing the above described information? From the experience gained and the success attained in investigating a special problem, the writer is inclined to answer this question in the affirmative, and a description of this special investigation is

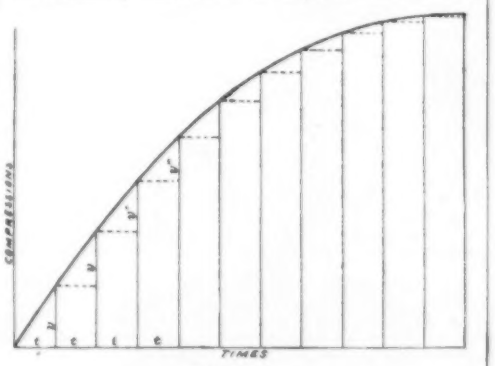


FIG. 2.

thought to be the best way to place the reader in a position to judge for himself.

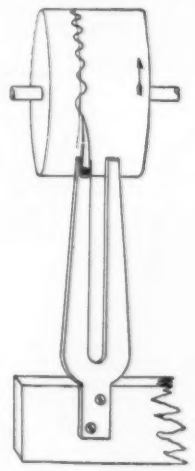


FIG. 3.

DYNAMIC MEASURE OF PRESSURE PRODUCED BY A BLOW.

An instrument, called the crusher gage, is used to measure the maximum pressures developed by the expansive force of fired gunpowder. It consists, essentially, of a housing which screws into the face of the breech block and incloses a small cylinder of pure annealed copper, half an inch long and a quarter of an inch in diameter. A hard steel piston (area one-tenth

* Paper recommended by the Franklin Institute for the award of the John Scott Legacy Medal and Premium.

of a square inch) moves in a gastight channel in housing and transmits the powder pressure to copper cylinder.

The effect of the pressure is to shorten the cylinder, and the exact amount of shortening is determined in each case by micrometer measurements made before and after firing. This shortening, or compression, is translated into maximum powder pressure by means of a "tarage table" constructed from static testing machine data. This data is obtained by compressing a series of similar cylinders in a static machine and recording the mean loads required to produce the successive compressions. Suppose, for example, that the static machine shows a load of 4,500 pounds to be necessary to compress the cylinder 0·2 inch, i. e., to change its length from 0·5 inch to 0·3 inch. It is assumed, then, that the maximum powder pressure on piston is 4,500 pounds—45,000 pounds per square inch—when the effect of it is to produce this 0·2 inch compression in the copper cylinder.

There are many interesting details concerning the construction and use of crusher gages that cannot be given here. It is desired only to show that the gage furnishes an excellent example of the enforced neglect of the element of time in measuring forces. The military engineer has been compelled to assume that the compression produced in this copper cylinder by a given pressure, applied slowly in the static machine, is identical with that produced by the expansive force of powder gases, applied and withdrawn within a few thousandths of a second. Theoretically, the effects cannot be the same. To produce compression, an appreciable mass, even in the copper cylinder itself, must be moved, and this requires time.

During the spring of 1891, the writer conceived the idea of compressing this copper cylinder by means of a blow and securing a dynamic measure of the cylinder's successive resistances.

By a proper selection of the mass and impact velocity of striking weight, any given compression can be produced in about the time consumed in producing the same compression in the gun.

Let us assume, for the present, that we have an apparatus which will record for us a curve such as shown in Fig. 2.

The ordinates of this curve represent the successive shortenings of copper cylinder during the delivery of blow, or the distances passed over by the weight after impact. The corresponding abscissas represent the times from instant of impact. The ordinates are separated by equal times, each equal to the smallest interval of time that can be accurately measured. This small interval is the unit of time, Δ t, used in measuring the total duration of blow. Since this total duration is to be limited to a few thousandths of a second, it is evident that our unit of time, Δ t, must be extremely minute, if we are to divide the total compression into a great number of parts. The differences between the successive ordinates divided by the time, Δ t, enable us to measure the successive velocities of the weight after impact. The differences of these successive velocities, divided by Δ t, give us the successive changes in weight's velocity, or the retardations due to copper resistance. The products of these retardations by the mass of weight measure the successive resistances of copper cylinder.

The process amounts simply to a graphical differentiation of the impact compression curve recorded as a function of the time of compression.

To obtain in this way a measure of the varying pressure produced by a blow, we must construct an apparatus capable of measuring simultaneously and with the greatest accuracy extremely minute intervals of time and space.

For all such measurements the first requisite is means for accurately magnifying the quantities to be measured. Only those who have had the experience can thoroughly appreciate the difficulties that had to be overcome in supplying an apparatus capable of dissecting the effect of a blow.

Let us trace briefly and separately the development of the time and distance measuring parts of the completed apparatus and then show their combination for simultaneous use.

TIME MEASUREMENT.

A tuning fork is used almost universally to subdivide a second of time. The method usually adopted is to attach a pen or stylus to one prong of the fork (see Fig. 3) and to cause a smooth metal surface coated with lampblack to be drawn past the vibrating fork. The point of pen, by plowing through the lampblack and exposing the bright metal surface, records a waving line, called a sinusoid. If the surface be drawn past while the fork is at rest, a straight line, called the median line, is produced. The width of record represents the fork's amplitude. The measured distances between the intersections of these lines show how far the recording surface moved during a whole or a half vibration of the fork. For smaller intervals of time it is usually assumed that the velocity of surface remains constant for the vibration interval.

It will be seen that the accuracy of time measurement will increase directly with:

1. The rate of the fork—a fork that divides a second into 1,000 parts being preferable to one that divides it into only 100 parts, just as a scale showing hundredths of an inch is preferable to one showing only tenths.

2. The velocity of recording surface. If we have one inch as the distance equivalent of the time of one vibration of fork, we can pass more accurately to a given fractional part of this time than we can when this distance equivalent is only one-tenth of an inch.

3. The clearness of intersections of median line and sinusoid.

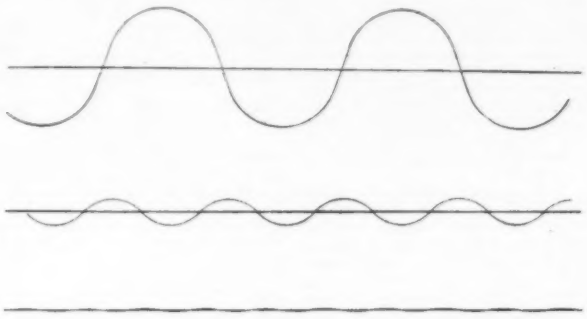


FIG. 4.

The upper record in Fig. 4 illustrates the use of a slow fork with large amplitude. The median line and sinusoid intersect at an obtuse angle, and it is easy to fix the points of intersection. The next record illustrates the substitution of a fork twice as fast as the first one. We thus divide a second into twice as many parts, but the amplitude decreases with an increase in rate of fork, and we observe a greater chance for error in fixing the points of intersection. The same trouble would follow a doubling of the velocity in recording surface.

If we continue to increase either the rate of fork or the velocity of recording surface, we shall obtain a result illustrated by the third record, wherein great difficulty would be experienced in fixing the points of intersection.

These conditions limit us, in the stylus method, to a fork of about 500 complete vibrations per second, and to a velocity of recording surface of about 10 feet per second.

It was evident that the above described method would not meet the conditions imposed upon the projected impact testing machine, and the writer entered, during the summer of 1891, upon the development of a new and an improved method. After successive steps, which involved a great many experiments, it was decided to substitute a sensitized photographic surface for the lamp-blackened metal surface and a beam of light for the stylus attachment to the fork.

FIG. 5.

The resulting time scale is illustrated by Fig. 5.

A hole with perfectly smooth edges is bored in the end of fork and illuminated by a concentrated beam of light. A lens placed between fork and sensitized surface produces a sharp and a magnified image of the edge of this hole. As the fork vibrates, the image moves up and down on the horizontally moving surface. The diameter of circular image is greater than the horizontal distance traversed by sensitized surface during the time of one vibration of fork.

Instead of being limited to $\frac{1}{10}$ of a second, the main divisions in this scale represent less than $\frac{1}{1000}$ of a second, and the velocity of recording surface was about 100 feet per second, instead of 10. The troublesome intersections of median line and sinusoid are here replaced by the intersections of the up and down curves, readily determined by causing the cross hair in microscope of measuring instrument to bisect the angle between curves. This operation is facilitated by the areas of double exposure in body of record, the points of which are directed toward these intersections.

When it is impracticable to secure uniform velocity in the recording surface—as, for example, when this surface is attached to a body having a varying motion which we wish to investigate—the main divisions in scale will be the smallest interval of time that we can measure accurately, and we should have as many sets of points separated by this interval as possible. In the stylus method we can get but two sets, since we have only one median line; but in the photographic record we obtain two sets from each shadow line. These shadow lines are cast by a grating of fine wires, or hairs, placed in close proximity to the sensitized surface and in the path of beam of light.

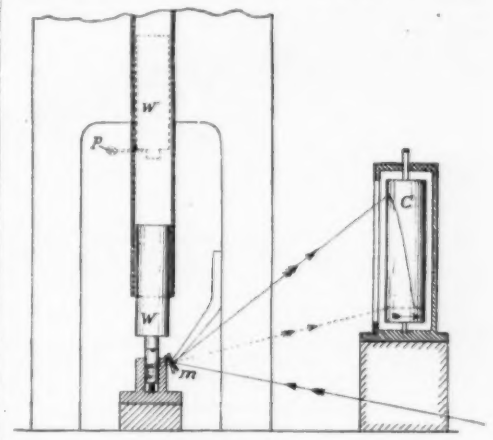


FIG. 6.

A more rapid fork could be used with equal facility, and the velocity of recording surface could readily be increased to 500 feet per second. By the method to be described later, this velocity can also be kept constant for a longer time than would be consumed in delivering the blow to be investigated. The use of a high fork is made practicable by the fact that we record, not the actual amplitude of fork, but the amplitude of movement in the magnified image.

Our ability to magnify the amplitude without affecting the wave lengths in time scale, and our control of the relation of diameter of image to these wave lengths, will always enable us to cause the up and down curves in record to intersect at about a 45° angle, the angle most favorable to an accurate determination of these intersections. The limits, in stylus method, to rate of fork and to velocity in recording surface are removed at once, and the effect of this removal may be compared with the effect upon accuracy of distance measurement of substituting a vernier caliper for a carpenter's rule. It is not necessary to dwell upon the advantages resulting from the substitution of the smooth sensitized for the rough, lamp-blackened surface, nor upon the advantage of securing a record of its vibrations without requiring the fork to do the mechanical work involved in plowing through the coating of lamp black.

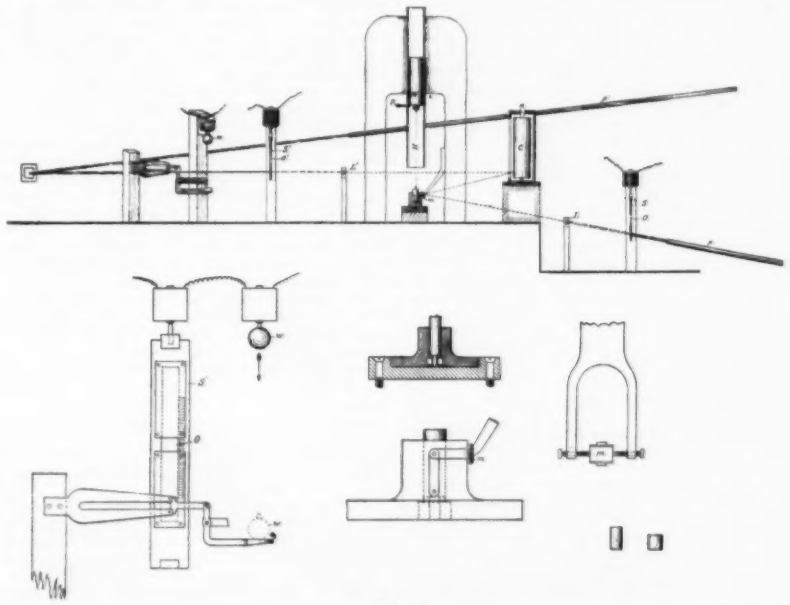


FIG. 7.

With a uniform velocity of 500 feet per second in sensitized surface—and to obtain this velocity it will be necessary only to give a 12-inch cylinder 10,000 revolutions per minute—we can readily detect an interval of time as small as one-tenth of a millionth of a second.

When we begin to subdivide a second of time on the

one hand, or to multiply the circumference of the earth on the other, we are unable, through absence of contrast, to appreciate through our senses the magnitudes of our results.

The smallest interval of time that photography enables us to measure is just about as much less than a second as the distance to the nearest fixed star is greater than the circumference of the earth, and yet it requires 3½ years for light from this star to reach us, the velocity of light transmission being 188,000 miles per second.

DISTANCE MEASUREMENT.

Fig. 6 illustrates the method devised to secure a magnified photographic record of the distance traversed by weight after impact, i. e., the compression of copper cylinder during delivery of blow.

A hardened steel piston rests on the copper, and a hardened steel plug is secured in the end of weight, W. The downward motion of piston after impact follows the compression of copper cylinder, the diameter of piston being such as to prevent any appreciable compression in the piston under the maximum pressure developed.

The small mirror, m, revolves about a fixed horizontal axis, and is connected with the piston by link work-in which the journals and pivots are ground to as accurate a fit as possible.

The cylinder, C, is rigidly mounted at a horizontal distance in front of mirror, determined by the magnifying ratio desired, and means are provided to revolve it at great speed about a vertical axis. The surface of cylinder is covered by a photographic film, a perfect glove fit being secured; or, if desired, the cylinder can be made of glass, ground true, and coated as the ordinary photographic plates are coated. A beam of light, after passing through a proper combination of lenses, is thrown on the small mirror, m, and reflected thence to the surface of cylinder, C. This beam traces its path on the sensitized surface and produces a curve whose ordinates are magnified reproductions of the downward motions of piston and hence of the successive compressions of copper cylinder.

We thus obtain the impact curve, which needs only a time scale, parallel to axis of abscissas, to enable us to construct a pressure curve for the copper specimen which will show the actual resistance offered by the copper at each stage of compression.

SIMULTANEOUS MEASUREMENT OF TIME AND DISTANCE.

The skeleton drawing, Fig. 7, illustrates the combined and simultaneous use of time and distance measuring apparatus.

The experiments are conducted in a dark room, and the two required beams of sunlight are reflected through pipes, p and p', from outside mirrors. The tuning fork is shown with a spreading wedge inserted between its prongs, ready to be withdrawn by impact of small weight, w', on end of lever. The weight, W, which strikes the blow on copper specimen, is released by withdrawing the metal pin which sustains it in the vertical guiding tube. The lens, L, produces a small and intense image of the sun on the surface of cylinder, C. This image moves upward during delivery of blow and traces the impact curve. The lens, L', produces a well-defined and enlarged image of the circular edge of hole in end of fork. This image traces the required time scale parallel to axis of abscissas of impact curve. These two beams of concentrated light must not be turned on until just before impact, and they must be turned off again immediately after completion of blow.

In the experiments made, the cylinder, C, completed about 100 revolutions per second, and it required only about one-third of one revolution to produce the desired records. The height of fall of the weight, W, varied from 7 to 15 inches. Gravity shutters, S and S', are shown suspended from electromagnets and in the paths of beams of light. The front view of one of these shutters shows an adjustable opening, O. During the fall of shutter this opening passes the beam, permits the light to reach the sensitized surface for the required interval, and then shuts it off again. The magnets which sustain the shutters, S and S', and the small weight, w, are energized by a current which passes through the metal guide cylinder and the pin which sustains the weight, W. A rapid tuning fork will vibrate only a short time, and for this reason it was desirable not to withdraw the wedge from this one until about one-hundredth of a second before impact. The drawing does not show the means provided to rotate the cylinder, C. This consisted, at first, of an electric motor, which was discarded because the varying wave lengths in time scale showed that the rotation of cylinder was not as uniform as was desirable. The motor was then replaced by a system of multiplying cog wheels and a drum, the cord from drum passing to an auxiliary falling weight of about 100 pounds. The end of cord was not fastened to drum, so that, when unwound, the cord was entirely disconnected, and the cylinder was left with its maximum speed to be gradually reduced by friction.

The auxiliary weight was used to operate an adjustable trigger, which withdrew the metal pin, P, and released the weight, W, at a time such that impact of W on copper specimen occurred just as the cord became disconnected from the drum. By this means the impact curve was recorded at the instant that acceleration in speed of cylinder, C, was passing through zero, and at this stage it was impossible to detect any variation in surface velocity. The frictional resistances being small, we should expect the rotation of cylinder, under these circumstances, to remain constant for the interval of time—not over 0·004 second—consumed in delivering the blow.

We can now trace the operation of this delicate mechanism.

After careful micrometer measurements of its length and its diameter, the copper cylinder is placed in position with the hard steel piston resting on it. The weight, W, is adjusted for the desired fall, which we will represent by H. The slides, S and S', are suspended and adjusted so that the distance of lower edge of opening, O, above upper edge of beam of light is less than H by a few hundredths of an inch, the exact difference being accurately calculated. A similar adjustment is made for the fall of small weight, w. The sensitized covering is placed over cylinder, C, and the wedge inserted between prongs of tuning fork. Assistants, outside the dark room, keep the reflected beams adjusted.

The apparatus is now ready to work automatically. The operator releases the auxiliary weight (not shown in drawing), and the cord which is attached to this weight begins to unwind from the drum. The rotation of cylinder, C, communicated from the drum through multiplying cogwheels, increases rapidly. When the auxiliary weight has fallen a determined distance, it operates a trigger and pulls out the pin, P. The withdrawal of this pin releases the weight, W, and breaks the electric current, so that the shutters, S and S', and the small weight, w, begin to fall. A few thousandths of a second before W strikes its blow, acceleration of cylinder speed is stopped by disconnection of cord from drum, the weight, w, by its action on lever pulls out the wedge and sets the fork vibrating; the opening, O, in shutter, S, is opposite its beam of light, and the image of sun formed by this beam, after reflection from rotating mirror (which is now stationary, since impact has not yet occurred), begins to trace the axis of abscissas of impact curve; the opening in shutter, S, permits a simultaneous appearance of the vibrating image of hole in fork to appear just under the sun image, on same vertical element of cylinder, where it begins to trace a refined time scale.

When impact occurs, the copper specimen yields under the pressure developed; the hard steel piston follows up this yielding; the small mirror revolves at a rate depending entirely upon movement of piston, and the sun image moves upward in a vertical plane, reproducing, on a magnified scale, the successive compressions of copper specimen. The resistance to compression offered by the copper, working over the path of compression, gradually absorbs the kinetic energy in weight, W, and reduces the velocity to zero. A wave of elastic compression in copper precedes the permanent set. This elastic recovery is observed, in the static testing machine, to be practically constant and equal to about 0·002 inch. It causes the weight, W, to rebound, and, after second impact, to rebound again a lesser distance, and so on until it is finally brought to rest, supported on the steel piston. These secondary blows do not increase the permanent set in copper specimen, and they should not, since their impact energies can never be greater than the work in elastic compression, wherein is found the source of the rebounds.

An observer, standing in the dark room and looking toward the revolving cylinder, sees on its surface, at the instant of impact, a brilliant vertical line of light whose duration is less than that of a flash of lightning. The photographic film on the rapidly spinning cylinder, however, has secured, during this inconceivably short interval of time, a permanent record of many important events and arranged them in chronological order, to be examined and studied at our leisure.

(To be continued.)

ON THE PROPERTIES OF LIQUID FLUORINE.

By Prof. HENRI MOISSAN, Membre de l'Institut, and Prof. JAMES DEWAR, M.A., LL.D., F.R.S.

THE nearest approach to the properties of the mythical alkahest or universal solvent of the alchemist is to be met with in fluorine. The transparent vessels in which it can be manipulated have to be made of some fluoride like fluorspar, and such vessels are equally difficult to construct and ill adapted for chemical manipulation. Modern research has, however, revealed the fact that the most powerful chemical affinities are completely suspended by allowing substances to come into contact at very low temperatures, and it appeared possible that even fluorine, which has the most powerful chemical activity of all the elements, might be manipulated in glass vessels under such conditions.

In a paper communicated to this society entitled "The Liquefaction of Air and Research at Low Temperatures" (Proc., 1895, 11, 221), speaking of fluorine, the author remarked: "This is the only widely distributed element that has not been liquefied. Some years ago, Wallach and Hensler pointed out that an examination of the boiling points of substituted halogen organic compounds led to the conclusion that although the atomic weight of fluorine is nineteen times that of hydrogen, yet it must in the free state approach hydrogen in volatility. This view is confirmed by the specific refractive index, which Gladstone showed was rather lower than hydrogen. If the chemical energy of fluorine at low temperatures is abolished, like that of other active substances, then some kind of glass or other transparent material not so brittle as calcium fluoride could be employed in the form of a tube, and its liquefaction achieved by the use of hydrogen as a cooling agent."

The inference that fluorine approached hydrogen in volatility was deduced by Wallach and Hensler from a consideration of the boiling points of the fluorine derivatives of the benzene series.

The following table:

I.

Benzene.	Boiling point.	Difference.	Toluene.	Boiling point.	Difference.
C_6H_6	80°	5°	$C_6H_5CH_3$	111°	5°
C_6H_5Fl	85°	47°	$p\text{-}C_6H_4Fl\cdot CH_3$	116°	44°
C_6H_5Cl	132°		$p\text{-}C_6H_4Cl\cdot CH_3$	160°	
Aniline.			**Benzene.**		
$C_6H_5NH_2$	183°	4°	C_6H_6	80°	8°
$p\,C_6H_4Fl\cdot NH_2$	187°	43°	$p\text{-}C_6H_4Fl_2$	88°	84°
$p\text{-}C_6H_4Cl\cdot NH_2$	230°		$p\text{-}C_6H_4Cl_2$	172°	

shows that the substitution of 1 atom of hydrogen in these compounds by fluorine only causes an increase of the boiling point of from 4° to 5°, whereas chlorine causes an increase of from 45° to 50°. Such a relatively large ratio as 1 to 10 in the increment of boiling points suggests a great difference in the volatility of the elements fluorine and chlorine in the free state. A further examination of the properties of fluorine compounds, however, showed that the volatility of fluorine was not likely to approach that of hydrogen. This will be apparent from the following table:

II.

Methane.	Boiling point (absolute).	Difference.	Ethane.	Boiling point (absolute).	Difference.
CH_4	110°	90°	C_2H_6	184°	58°
CH_3Fl	200°	50°	C_2H_5Fl	242°	44°
CH_3Cl	250°		C_2H_5Cl	286°	
CH_4	110°	149° = 4 × 37°	$C{\cdot}H_4$	110°	241° = 4 × 60°
CFl_4	259°		$C{\cdot}Cl_4$	351°	
Aldehyde.	**B.p. (C.)**		**Benzaldehyde**	**B.p. (C.)**	
CH_3COH	21°	−11°	C_6H_5COH	179°	−18°
CH_2COFl	10°	41°	C_6H_5COFl	161°	38°
CH_2COCl	51°		C_6H_5COCl	199°	

where it is seen that the substitution of hydrogen by fluorine in methane and ethane raises the boiling point by 90° and 60° respectively, and that the ratio of the increments of boiling point in corresponding fluorine and chlorine compounds is now not greater than 1:2. The boiling point of methyl fluoride was calculated from the critical point and vapor pressure of this substance as recorded by Prof. Collie (Trans., 1889, 55, 110). It will be noted as a curious fact that the substitution of fluorine in the aldehyde radicle causes a lowering of the boiling point and not an increase, and that the difference in boiling point between the chlorine and fluorine substitution body in either series is always between 40° and 50°. These considerations induced the hope that liquid air might give the command of a sufficiently low temperature for the liquefaction of fluorine and that glass vessels might be used to collect the liquid. This view was supported by a consideration of the melting points of the halogens and the corresponding critical points deduced by following the suggestions of Clarke (Am. Chem. Soc. J., 1896, 18, 618) as to these relations. Thus the absolute melting points of chlorine, bromine, and iodine are respectively 171°, 267°, and 388°, and, assuming the same mean difference in melting point extended to fluorine, then its melting point would be 64° absolute. Now the critical points of chlorine and bromine are about 2½ times the absolute melting points, thus giving 149° absolute, or −125°, as the probable critical point of fluorine. This critical value is only a few degrees lower than oxygen, and from this calculation the authors were entitled to assume that the position of fluorine as regards volatility would be somewhere between that of oxygen and nitrogen.

The following research was conducted in the Chemical Laboratory of the Royal Institution, to which Prof. Moissan brought the apparatus for the production of gaseous fluorine with which his name will always be identified, and the authors had the invaluable assistance of Messrs. Lebeau, Lennox, and Heath in the conduct of the experiments.

Fluorine was prepared by the electrolysis of potassium fluoride in solution in anhydrous hydrofluoric acid. The fluorine gas was freed from vapors of hydrofluoric acid by being passed through a serpentine of platinum cooled by a mixture of solid carbonic acid and alcohol. Two platinum tubes filled with perfectly dry sodium fluoride completed the purification.

The apparatus used for liquefying the gas consisted of a small cylinder of thin glass, to the upper part of which was fused a platinum tube. This latter contained in its axis another smaller tube, likewise of platinum. The gas to be liquefied enters by the annular space, passes through the glass envelope, and escapes through the small inner tube. The glass envelope was fused to the platinum tube by which the fluorine was supplied.

The glass cylinder being cooled down to the temperature of boiling liquid oxygen (−183°), the current of fluorine gas passed through the bulb without becoming liquid. At this low temperature, however, the gas has lost its chemical activity, and no longer attacks the glass.

On lowering the temperature of the liquid oxygen by exhaustion, a yellow liquid is seen collecting in the glass envelope, while gas no longer escapes from the apparatus. At this moment the tube by which the gas had been escaping is stopped, so as to prevent air from entering and liquefying, and the glass bulb soon becomes full of a clear yellow liquid, possessed of great mobility. The color of this liquid is the same as that of fluorine gas when examined in a stratum one meter thick. Fluorine thus becomes liquid, according to this experiment, at about −185°.

When the bulb containing the liquid fluorine is lifted above the surface of the liquid oxygen, the yellow liquid begins to boil with an abundant disengagement of gas, having all the energetic reactions of fluorine.

Silicon, boron, carbon, sulphur, phosphorus, and reduced iron, cooled in liquid oxygen and then placed in an atmosphere of fluorine, did not become incandescent. At this low temperature, fluorine did not displace iodine from iodides. However, its chemical energy is still sufficiently great to decompose benzene or oil of turpentine with incandescence. It would thus seem that the powerful affinity of fluorine for hydrogen is the last to disappear. The authors have noticed on some occasions that a current of fluorine gas passed into liquid oxygen gives a flocculent precipitate of a white color, which quickly settles to the bottom. If this mixture is shaken and thrown on a filter, the substance can be collected. It possesses the curious property of deflagrating with violence as soon as the temperature rises.

A new apparatus (Fig. 1) was constructed similar to that already described (that is to say, a glass bulb, E, fused to a platinum tube, A, which contained another similar smaller tube, D), but having each of the platinum tubes, B and C, fitted with a screw valve, in such a manner that at any moment communication—either with the outer air or with the current of fluorine—could be interrupted. This little apparatus was placed in a cylindrical glass vacuum vessel containing

liquid oxygen, connected with a vacuum pump and manometer.

On repeating the former experiment with freshly prepared liquid air, instead of oxygen, fluorine easily becomes liquid at —190° C. With liquid oxygen as refrigerant, the liquefaction of fluorine takes place at a temperature corresponding to the evaporation of the oxygen under a pressure of 437 millimeters of mercury.

From these two experiments it results that the boiling point of fluorine is very close to —187°. This number is identical with Olszewski's boiling point of argon; so that this seems to be the first example of two gaseous elements boiling at the same temperature. It is a justifiable inference from the boiling point that the critical point must be about —120°, and thus, in all probability, the critical pressure is about 40 atmospheres, or less than half that of the critical pressure of chlorine, which is 84 atmospheres. This would make the critical constant for fluorine 4 as contrasted with chlorine, which has the value 5.

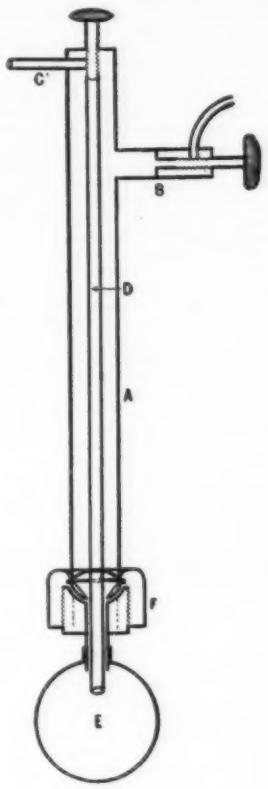


FIG. 1.

The following table gives the boiling points of the halogens:

	Absolute temperature.	Differences.
Fluorine	87°	153°
Chlorine	240°	97°
Bromine	337°	123°
Iodine	460°	

When the little glass bulb was three-quarters full of liquid fluorine, both the valves were closed, and then a good air pump caused the liquid oxygen serving as refrigerant to boil rapidly at a pressure of 2·5 centimeters. Under these conditions, a temperature of —210° is reached, yet the fluorine did not show any sign of solidification, but retained its characteristic mobility. In future experiments it will be interesting to try the rapid ebullition of the liquid fluorine itself. During the repetition of this experiment a slight accident occurred. The screw of one of the valves becoming worn, allowed air to leak into the exhausted bulb. This air was immediately liquefied, and in a few moments two distinct layers of liquid were seen; the upper, colorless layer consisted of liquid air; the lower one, of a pale yellow color, being fluorine.

To prevent the possible ingress of any air, the fluorine was introduced in its liquid state into a glass tube, the end of which was then sealed before the blowpipe. The sealed tube, containing the liquid fluorine, was kept for a long time at —210° by the rapid evaporation of a large quantity of liquid air, but it gave no trace of a solid body.

To determine the density of liquid fluorine, it was brought into contact with a number of bodies whose density is known, comparing their behavior at the same time in liquid oxygen, which has about the same boiling point and density. By taking groups of bodies whose densities are very close to each other, it is easy to see which sink and which float in the liquid. This well-known though indirect method was the most suitable for these delicate experiments. The authors first satisfied themselves that the fluorine had no action on the materials used. To effect this, a crystal of ammonium thiocyanate (density = 1·31) was placed in a glass tube surrounded with boiling liquid air to the bottom of the tube, a current of fluorine gas was introduced by means of a platinum jet. The fluorine was rapidly liquefied, and the ammonium thiocyanate was not attacked. The same experiment was repeated with a fragment of ebonite (d = 1·15), of caoutchouc (d = 0·99), of wood (d = 0·96), of amber (d = 1·11), and of methyl oxalate (d = 1·15). It is of importance, in the experiments just mentioned, that the various materials used should be first kept at a temperature of —190° for some little time before coming in contact with liquid fluorine.

In one of the experiments a piece of caoutchouc, having been insufficiently cooled, took fire on the surface of the liquid, and burned completely away with a brilliant flame without leaving any residue of carbon. The piece of caoutchouc ran about the surface of the liquid like sodium on water, giving a very intense light.

The density experiment was carried out in the following manner:

In a glass tube closed at one end, and of which the lower part had been slightly drawn out, fragments of the five substances just mentioned were placed. The tube was then plunged to a third of its length into boiling liquid air. When it was all reduced to a temperature of about —190° the fluorine gas was carefully introduced. This soon liquefied, and the wood and the caoutchouc floated easily on the surface of the pale yellow liquid. On the other hand, the methyl oxalate and ebonite remained at the bottom, while the amber rose and fell in the liquid, appearing to be of the same density. The apparatus was shaken several times, and the quantity of liquid fluorine increased, but the results were the same.

The authors thus arrive at the conclusion from these experiments that the density of liquid fluorine is about 1·14. Another point which appears to be of interest is the following: The fragment of amber floating in the fluorine was very difficult to distinguish, which would seem to indicate that the index of refraction of liquid fluorine is in any case greater than that of liquid air or oxygen, although it is not likely to be so high as that of amber itself.

Fluorine was liquefied in a thick-walled glass tube which had been previously graduated, and the tube sealed. On cooling the tube and its contents to —210°, a contraction of $\frac{1}{14}$ in the volume of the liquid fluorine took place. A similar tube was left alone in a vacuum vessel full of liquid air. One hour and one-half afterward, the tube still being in liquid air, the fluorine had not changed in appearance. But shortly afterward, when the air had all evaporated, a violent detonation occurred; the sealed tube and the double beaker in which it had been placed were smashed and reduced to powder.

Different samples of liquid fluorine examined with the spectroscope through a thickness of about $\frac{1}{2}$ centimeter showed no specific absorption bands in the visible spectrum.

Liquid fluorine placed between the poles of a powerful electromagnet does not show any magnetic phenomena. These experiments are the more decisive, as comparative ones with liquid oxygen were made at the same time.

The capillary constant of fluorine is smaller than that of liquid oxygen. A capillary tube, plunged successively in fluorine, oxygen, alcohol and water, gave the following figures:

Height of liquid fluorine	3·5 mm.
" " " oxygen	5·0 "
" " alcohol	14·0 "
" " water	22·0 "

Liquid fluorine placed in a glass tube surrounded with liquid air (temperature about —190° C.) had a slow current of hydrogen gas directed onto its surface by means of a fine platinum jet. There was immediate combustion with the production of flame. The experiment was repeated by dipping the platinum jet well below the surface of the liquid. At this temperature complete combination still took place, with a considerable evolution of light and heat.

Oil of turpentine, in the solid state, is attacked by liquid fluorine. To perform this experiment a little oil of turpentine was placed at the bottom of a glass tube surrounded with boiling liquid air. As soon as a small quantity of fluorine was liquefied on the surface of the solid, combination took place with explosive force, a brilliant flash of light, and deposition of carbon. After each explosion the current of fluorine gas was kept up slowly, a fresh quantity of liquid fluorine was formed, and the detonations succeeded each other at intervals of from six to seven minutes. Finally, after a longer interval of about nine minutes, the quantity of fluorine formed was sufficient to cause, at the moment of the reaction, the complete destruction of the apparatus. In several of these experiments a little liquid fluorine accidentally fell on the floor; the wood instantly took fire.

The action of liquid oxygen has been studied with more care since the authors observed that by passing a current of fluorine through liquid oxygen, a detonating body could be produced.

If a current of fluorine is directed to the surface of liquid oxygen in a glass tube, the temperature being about —190°, the fluorine dissolves in all proportions, imparting a yellowish color, and giving the liquid a graded tint from the upper to the lower part; the bottom of the tube is hardly colored. If, on the contrary, the fluorine gas is introduced at the bottom of the liquid oxygen, the yellow color is produced at the bottom and diffuses slowly to the upper layers.

This phenomenon indicates that the densities of liquid fluorine and oxygen are very near each other. When the temperature of the mixture of liquid oxygen and fluorine is allowed to rise slowly, the oxygen evaporates first. The liquid becomes more and more concentrated as regards fluorine, and finally the latter begins to boil in its turn. In fact, at the commencement of this boiling the gas coming off will light a match which has only a red-hot point, and will not make lampblack or silicon red hot; but, on the other hand, the gas coming off at the end of the experiment will instantly cause these two latter bodies to burst into flame. When the glass bulb is completely empty and its temperature is rising, a distinct disengagement of heat is suddenly noticed, and the interior of the glass loses its polish. This rise in temperature is due to the fluorine gas attacking the glass. In this experiment, using perfectly dry oxygen, no precipitate is produced. If, on the contrary, oxygen is used which has been some hours in contact with the air, the detonating substance mentioned in previous experiments is produced.

The body which is produced by the action of fluorine on oxygen containing in suspension minute crystals of ice seems to be a hydrate of fluorine, decomposing, with detonation, by a simple rise of temperature. This view must, however, be taken as conjecture until the real composition is ascertained. A small quantity of water at the bottom of a glass tube being cooled down to —190°, liquid fluorine formed on the surface of the ice as a mobile liquid without showing any chemical action, and evaporated on the temperature rising. As soon as the apparatus became warmer, the remaining gaseous fluorine attacked the ice with great energy, causing a strong smell of ozone.

A globule of mercury was treated in the same way as the water described above. The surface remaining very brilliant, the liquid fluorine surrounded it without causing any diminution of metallic luster. On allowing the temperature to rise, the fluorine began to boil, and the liquid disappeared completely, without any attack of the mercury. The experiments seem to warrant the following conclusions:

Fluorine gas is easily liquefied at the temperature of boiling atmospheric air. The boiling point of liquid fluorine is —187°. It is soluble in all proportions in liquid oxygen and in liquid air. It does not solidify at —210°. Its density is 1·14, its capillarity is less than that of liquid oxygen; it has no absorption spectrum, and it is not magnetic.

Finally, at —190° it has no action on dry oxygen, water, or mercury, but it reacts, with incandescence, on hydrogen and oil of turpentine. Future experiments must decide whether cooling below —200° can suspend the powerful chemical action of liquid fluorine on hydrogen and hydrocarbons.

One of the most important questions for future investigation is the specific refractive and dispersive indices of the fluid. Davy, in his paper on the substances produced in different chemical processes on fluorspar (Phil. Trans., 1813, 278), says: "Dr. Wollaston has found that the fluoric combinations have very low powers of refracting light, and particularly the pure fluoric acid; so that the refracting powers of fluorine will probably be found lower than those of any other substance, and it appears to possess higher acidifying and saturating powers than either oxygen or chlorine."

Gladstone has shown that the specific atomic refraction of the combined element does not exceed 0·9, taking the Lorentz formula, and that the atomic dispersion diminishes instead of increasing for short wave lengths. Further, he found that the other halogen substitution compounds gave atomic refractions nearly agreeing with the same substances in the free state. It has been found that liquid gases give the same atomic refraction as the gaseous body, so that the refractive index of liquid fluorine may be at once deduced, provided it behaves like chlorine, bromine, or iodine. Taking 0·9 as the atomic refraction, the value would be according to the Gladstone formula, 1·054, and the Lorentz, 1·081. Both values are far lower than those of liquid oxygen or air, 1·226 and 1·205 respectively. The general appearance of the liquid and the experiment with amber described above lead to the conclusion that liquid fluorine must have a refractive index much higher than that calculated. If the refractive index is as great as 1·41, then the atomic refraction (Lorentz) will be 4·13, but if it is only about 1·192, then the atomic refraction will be 2. On both assumptions the atomic refraction of liquid fluorine is much greater than the value 0·9 found by Gladstone. Should the smaller value 2 turn out to be the correct one, then the inference might be fairly drawn that the critical constant was also about 3, or nearly the value for oxygen. This view would make the critical pressure of fluorine about the same as that of oxygen, or 50 atmospheres. From this it would follow that, unlike chlorine, bromine and iodine, which have the same atomic refraction in combination and in the free state, fluorine has a different value in the one state as compared to the other. In this respect it would appear to resemble oxygen, whose atomic refraction in combination may be only three-fourths of what it is in the free state. This view is confirmed by an examination of the atomic volume of fluorine. The other members of the halogen series have approximately the same atomic volume in combination as in the free state. Now, the atomic volume of fluorine in fluorbenzene is 11·5, or about half the atomic volume of chlorine, or taking chlorobenzene as standard, with chlorine as 22·7, then the atomic volume would be 10. The value for the free element appears to be 16·6, and the number deduced from liquid hydrofluoric acid about 15. Many metallic fluorides have relatively small atomic volumes. Thus the fluorides of cadmium, lithium, calcium, magnesium, and aluminum have an atomic volume just about half of that of the corresponding chloride. This difference is, however, easily explained if fluorine in the combined state has only half the atomic volume of chlorine. Dr. Thorpe's value for the atomic volume of fluorine, deduced from a study of the chloride and fluoride of arsenic, is 9·2, or free fluorine at its boiling point ought to have a density of 2, provided it behaved like the other halogens. This density for the free element is much too high, the experimental value being about 1·14. Such changes in atomic volume again suggest a resemblance with oxygen, and would lead to the inference that the refractive constants must also differ in the free and combined states. These interesting problems must, however, be left for future investigation.

DISEASES OF LONDON.

LONDON is said to be the healthiest city in the world of its size, says The Humanitarian. Then it has to be remembered that there is no other city of the same size as London. The numerous hospitals are evidence of the great prevalence of disease within its borders, and the activity of the coffin makers and undertakers is well known when the fogs come on. Some interesting figures have recently been given showing the cases treated at the voluntary hospitals and dispensaries of London, and also at the hospitals of the Metropolitan Asylums Board. They amounted together to the total of 1,753,611 patients, and the following are some particulars of the various classes of disease represented in that total:

Surgical diseases	847,476
General medical diseases	558,309
Treated at children's hospitals	127,272
Eye affections	109,028
Diseases of motherhood	70,640
Consumption	47,236
Ear and throat	43,290
Diseases of the skin	39,131
Fever	21,815
Paralysis and diseases of the nerves	16,677

A NEW GOBELINS TAPESTRY.

AT the Exposition of 1900 the Manufacture Nationale des Gobelins will be represented by some pieces of work worthy of its past reputation, that were put in the loom a few months ago, and will be finished in due time. Among such pieces we may mention just at present the "Romance in the Eighteenth Century," an allegorical composition in the style of the epoch. M. Maurice Leloir, whose reputation is already made, is the author of this charming model, of which a very accurate idea is given in the accompanying engraving.

Interpreted by the skillful artists of the Gobelins, the coloring, which in the original is very harmonious, will be of the happiest effect. The figures, clad in the costumes in fashion at the time, are ingeniously grouped amid flowers and ornaments of the Pompadour kind, and those of our readers who are somewhat erudite will at once recognize in the principal figures the heroes and heroines of the most widely known romances.

To the left we have Estelle plying her distaff, Manon Lescaut contemplating herself in a mirror, then the Julie of La Nouvelle Heloise, and finally, Virginie interweaving a garland. Above, to the right, we see the busts of J. J. Rousseau and Bernardin de Saint Pierre, and, to the left, those of Florian and Abbot Prévost.—Le Magasin Pittoresque.

A NEW GOBELINS TAPESTRY—"LE ROMAN AU XVIIIe SIECLE."

ICE HOUSES.*

YOUR committee appointed to report on the subject, "Designs for Ice Houses," feel that their work would be but begun were we to present as our report merely a collation of designs showing ice houses, either proposed or constructed. We, therefore, beg your indulgence in a rather fuller discussion of the subject than the mere title of this report would suggest.

As the necessity for one or more ice houses for railroad purposes presupposes the use of ice by the carrier, it seems desirable at the very outset to give some consideration to the question from the standpoint of the traffic and transportation departments. Let us consider, therefore, (1) for what purposes, in what quantities and where ice is needed; (2) how it is proposed to obtain it, and how delivered to the house; and (3) how distributed to meet the needs. This information must be given in order that the subsequent designs shall meet, as nearly as possible, the requirements without necessitating too great an outlay and permit of handling the ice at the lowest possible cost for labor and the smallest percentage of waste or loss.

The ice may be used in refrigerator and dining car service, station, office and coach water coolers and station and coach urinals; the quantities of ice used for each purpose vary widely on different roads. The point or points where the ice is needed is determined by the transportation and traffic departments, usually to best serve the needs of the refrigerator car service.

The supply may be obtained by manufacture, by cutting from ponds, etc., in season, and storing the entire year's supply, or from contractors as needed. It may be brought to the storehouse on endless belt, wagons, cars or boats.

The distribution is usually made from large or main storage houses by periodical shipments in box or refrigerator cars to points of minor distribution—infrequently in baggage cars of passenger trains, though in the latter case, of course, with much loss.

The location of the ice house is practically independent of the location of the proposed source of supply; the need of a large storage house becomes apparent only when the use of natural ice in considerable quantities is contemplated, and at the time the crop is harvested the temperature (in the central and northern parts of the country) will be so low that the ice can be hauled long distances, if necessary, with slight loss, the main part of which will be from breakage of the cakes.

But your committee feels that attention has not been sufficiently directed to the manufacture of its own ice by the road needing a supply. While on Southern roads especially such a proposition would in many cases be most forcibly presented by the traffic department in the light of the influence of a sufficient supply of ice in controlling or even handling the dressed meat, dairy and fruit trade, it still devolves upon the engineer to prepare estimates of cost as between the two plans.

The cost of the natural ice supplied will vary so much in different localities that it is impossible to take any figure as an average cost to cover the case generally. Where in one case it may be 50 cents per ton put in the house, in another house on the same road the cost may run up to $1.25 or more in the house, and that although the different contracts were all placed at the same time prior to or during the winter season. At other times of the year, of course, prices run much higher. Until the stock is actually housed there is in this latitude much cause for worry whether a full supply can be secured at any reasonable price. The demand for ice varies much as between different years, the main causes therefor being differences in severity of seasons and fluctuations in volume of refrigerator car business handled. Of course, a full supply must be stored during the cold season, but in the event of but little ice being used during the ensuing year, a heavy loss is entailed. The shrinkage of such a stock we have known to amount to about 55 per cent. of the total.

With the manufacture of its own ice the road is independent of the season, can control the output to suit the requirements, secure an article sanitarily pure and avoid the expense of large storage houses, keeping only sufficient in storage to be prepared for emergency calls. We deem this question of the manufacture of ice by the road of sufficient importance to warrant the submission herewith of a plan, specifications and estimate for a 25 ton and 50 ton plant under the conditions to be met in New York City. These figures of cost include the plant complete (except the land on which it stands), including storage rooms, each of 250 and 500 tons' capacity respectively, and refrigerating apparatus for keeping the ice in these rooms. This estimate is for a plant of the absorption type, but no discrimination is intended as against the compression system; each has its field of greater usefulness and higher efficiency. The main point to which we wish to call attention is the cost per ton of the ice as shown; this cost includes all items except water. Of course, such an installation would be even more profitable to operate where as a side issue refrigerating effort could be supplied to cold storage rooms, such as certain roads now operate. One large road running out of New York has now in operation a 50 ton ice-making machine (compression type) which, with slack coal at 66 cents per ton and common labor at 12 cents per hour, will, when running at full capacity, turn out the ice at a cost for operation of between 50 cents and 55 cents per ton.

Although the showing made by refrigerating plants is attractive, we shall assume in our further discussion the use of natural ice by the carrier, as that is the more commonly used.

There are relatively very few points where a small ice house is needed. For general station purposes a plentiful supply of good water is necessary; this is secured in small outlying towns and villages by either a pump or well at the station or from the local water system; here ice for station water coolers is not needed, and for sanitary purposes in the toilet rooms some such agent as chloride of lime answers better than ice. Where the size and importance of the town demands the use of ice, it may be found cheaper to procure this small supply from local dealers as needed; but should several such places be grouped together on the line, it may be found desirable to locate at one of these points a small house; this will certainly be the case if local passenger trains are started from that point, as ice in coach water coolers is, during the summer season especially, practically necessary, and in coach urinals is highly desirable. It almost goes without saying that an ice house should be located at or adjacent to each division terminal. Such a house should be built on the same design as the larger houses, with dimensions so altered as to meet the requirements of that particular locality.

Ice houses for storing ice to be used for special purposes, such as icing refrigerator cars, are built according to the standard design, but are further equipped with special appliances for handling ice, breaking and carrying it and mixing with salt. Where the ice is to be used for but the single purpose, machinery for its handling may be introduced which will prove, if properly designed or adapted to the needs, highly economical.

In all ice house construction the most important consideration is the:

Insulation.—The ideal ice house is simply a storage chamber absolutely protected on all sides against the absorption of external heat and supplied with well designed drains for the prompt removal of all water resulting from the little melting that, in spite of all practicable precautions, will occur. Heat travels or is conveyed by radiation, conduction and convection. For the purpose of this discussion the outside of the building and the ground (however themselves heated) may be assumed to be the source of the heat against which it is desired to insulate the storage chamber. Experiment has shown that cells or small chambers of dry, dead air form the best insulator. In the proportioning of these air spaces two facts must be borne in mind: (1) the intensity of radiant heat varies inversely as the square of the distance from the source, and (2) soon as a current, however slight, of air is formed in any air space, heat is carried by convection around in that chamber. Of course, two air spaces are more effective than one, and three more than two, but there is an economic maximum dependent on the circumstances of each case.

Material of Construction.—Wood is best adapted for use in buildings of this character, being of itself a non-conductor of heat, and not retaining the heat, as does either natural or artificial stone, it permits the cheapest and at the same time the most efficient construction. In some municipalities certain regulations have been established governing the construction of all buildings within the "fire limits," and such laws usually are directed first to the materials of construction; at such a point it will be well to consider the advisability of locating the proposed ice house beyond these fire limits to conserve the use of wood in the construction.

Plan.—All ice houses should be built in sections, the size of section being governed by the quantity of ice used; in some cases it is advisable to construct across each section lateral partitions which will still further reduce the amount of ice exposed to contact with the outer air while part of the stock is being removed. The building should stand with the gable end of the sections to the track, the doors then coming in the ends of the sections. At the center of each section and at about the level of the first door should be placed a platform, say 6′ × 10′.

Proportions.—Assuming that a cubic foot of ice

* Report of a committee consisting of Messrs. W. B. Yearance and C. M. Large to the officers and members of the Association of Railway Superintendents of Bridges and Buildings.—From The American Architect and Building News.

weighs 57·2 pounds, a ton of solid ice would occupy about 35 cubic feet. Some years since 40 cubic feet were considered ample in which to store a ton of ice cut in such sized cakes as are usually stored, but that allowance has been increased to 45 and even 50 cubic feet. In storing ice good practice requires each cake to be stood on edge, leaving at least an inch air space on four sides of the cakes. Ice less than 10 inches in thickness or not perfectly solid it does not usually pay to store; the thicker it is the better, but the cakes in any one layer should be all of the same dimensions to secure the best results. The layers should be crossed. The practice of laying each cake on the flat and as close as possible to those adjacent and filling all interstices with finely broken ice is to be condemned—it costs more for labor, the wastage is greater than in the method before described, and when the ice is to be taken out it is difficult to get good merchantable cakes.

No covering should be placed on the ice after it is in place in the house; an inorganic substance, such as asbestos, would make the ice dirty and be too expensive to use; any organic matter, such as that generally employed—hay or sawdust—not only dirties the ice, but, being dampened by the melting, soon begins to rot, decompose and become foul. For this reason the use of any organic matter between walls is to be deprecated. The use of short fiber asbestos in the outer air space has been suggested, but not, to our knowledge, tried; however, at a weight of 12 pounds per cubic foot and at a cost of $16 per ton in carload lots, f. o. b. New York, the expense is practically prohibitory. This asbestos, if used loosely, as it should be if at all, settles after being wet, and though it still retains its spongy character, is reduced in volume, leaving the upper portion of its confining chamber empty.

Site.—While little scope is usually given in the selection of a site, there are certain precautions to be taken in order to secure a good bed. If the site chosen be on a little rise above the adjacent ground level, surface drainage will give no trouble; otherwise provision for it, as well as for the water from the melting ice, must be made.

Preparation for the Bed.—Assuming the ground to be good, the excavation below frost line is made for the house foundations, and about two feet in depth inside the foundation for the reception of the bed. If the digging shows a clay soil, drains should be provided to carry off the water from the ice, and these drains should be air trapped.

Cinders or gravel should then be placed in the excavation as a bed whose top should be raised slightly above the surrounding ground level and inclined with an easy and gradual slope to the center. On this bed, before ice is stored, rough hemlock plank should be laid with, say, two-inch spacing to keep the ice off the bed itself, yet permit the water to pass through readily. A good concrete floor, well drained from the center, would make a better job and be more satisfactory, but its cost precludes its general use in construction of this class.

Foundations.—The foundations also, whether of wood, brick or stone, should contain an air space as a further insulation; heat may reach the storage chamber as well under as through the walls; in some cases this we know is the case.

Construction.—It is claimed by some that the side walls should be constructed with a batter, but your committee do not approve this idea; the idea is evidently to relieve the side walls of any pressure that may be brought upon them by the spreading of the mass of ice as it melts, but if the slightest care has been exercised in the storing of the stock, that condition will not be found to exist, especially as the ice naturally melts most on the outside of the mass; at any rate, in order to be effective, assuming such a condition to exist, the batter would have to be increased over any we have yet heard proposed.

If considered necessary, to resist wind pressure, etc., the sills may be tied to the foundation. They should, on a brick or stone foundation, be laid in a lime mortar in any event. The sheathing, with the exception of the outside, may be rough. While there will be three extra courses of this rough sheathing over what is usually found, the lumber is cheap and the results obtainable will fully warrant the slight increase in cost.

The paper used should be saturated (not painted or coated) and laid with laps to the center of the sheet, virtually giving, then, two thicknesses of the paper in each lining. The sheets should be well cemented together and the paper tacked securely to the sheathing. A paper similar in character to the "Giant" of the Standard Paint Company is recommended, which, running, say, 80 to 85 pounds per roll of 36 inches width and containing 1,000 square feet, will cost about $6.25 per roll in place, including cement and tacks. With this paper should be used a cement similar to that used for roofing purposes, which must be flexible (not brittle), strong, inodorous and lasting. The job, when properly done, will make each space air and water tight. The construction here recommended is the best practice of commercial cold storage houses, only so modified as to be cheap to construct, while yet retaining practically all the advantages of a more expensive construction.

At each gable end ample ventilators should be placed, permitting a free and full current of air over the ceiling of the storage chamber. The roof should be shingled and the valleys between sections well lined. There is nothing, apparently, gained by having the doors, through which to handle the ice, vertically continuous. A stiffer frame, freedom from excessive sag of the lower doors and a closer, tighter fit of each door are secured by introducing a stiff sill framed under each door.

As may be inferred from the foregoing, we do not approve the use of tie rods to "stay" the sides of the sections, because of their unreliability; they must of necessity sag under the weight of the superimposed ice and then they either spring the side walls in or, because of the low temperature and tension to which they are subjected, break; even in the latter event they spring the side walls more or less before they let go.

A rigging amply stayed should be located over each line of doors to take the hook of the pulley for the hoisting rope in handling the ice in and out of the house.

A couple of coats of a good, light colored zinc paint should be applied to the outside of the house.

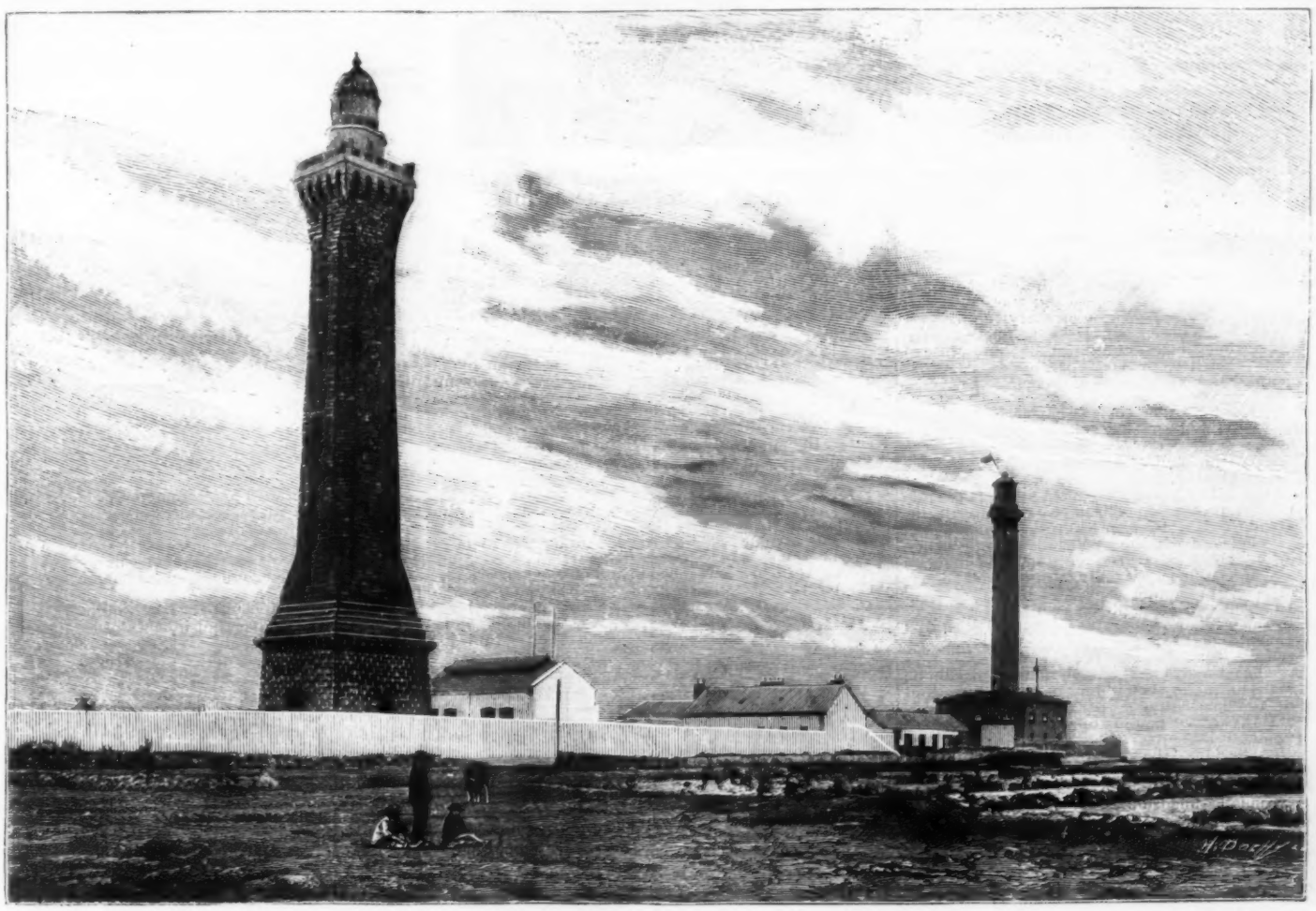
In a general report, to cover such a variety of conditions as are to be met in the service of the roads here represented, it is manifestly impossible to give any proportions that may be used in all cases. We, therefore, are unable to give an estimate of cost for such a house as is herein discussed for all localities. However, that will be no difficult matter for any one familiar with the conditions to be met to compile. Should three or even four air spaces be found necessary, sufficient data is here given to enable the one in charge to make his estimate on the design recommended.

THE ECKMUHL LIGHTHOUSE AT PENMARCH.

THE tempestuous and powerful sea that lashes the jagged sides of the extreme west coast of Armorica is strewed with rocks, and its granitic coast is everywhere covered with dangerous reefs.

There are already more than fifty lighthouses of the most improved type strung along from the island of Four to Penmarch, over an extent of less than twelve miles, and the government engineers have erected beacons everywhere upon these shores. But this is not yet enough for the sea of shipwrecks and the formidable coast of wreckers. This region requires powerful and sonorous electric alarms. The generous posthumous thought of the Marchioness de Blocqueville, née Davout d'Eckmühl, daughter of a marshal of France, has just crowned the humanitarian wish of the state as concerns the dangerous point of Penmarch.

At the extreme point of Penmarch stands a lighthouse 135 feet in height, but which is recognized as inadequate as a beacon for a locality so dangerous as this. So the commission appointed by the government, together with Mme. De Blocqueville's executor, selected the point of Penmarch for the establishment of the powerful Eckmühl lighthouse, in which are combined all the latest improvements in the science of optics and illumination, and which is the completest installation of the kind that exists in our day. Begun September 18, 1893, the work upon it lasted just four years, and it was inaugurated and lighted up for the first time on the 17th of last October, in the presence of the Eckmühl family and the head functionaries of the department of government engineers and the Minister of Public Works.



THE NEW ECKMUHL LIGHTHOUSE AT PENMARCH.

The Eckmühl lighthouse is situated at the extreme west and at the point of the large and desolate peninsula of Penmarch, which is covered with ruins and jagged rocks. Located at three hundred feet only from the old lighthouse, which is to be extinguished at the time that the new one is lighted, this structure rises to a height of 210 feet above the highest tide. It is a superb and gigantic octagonal tower of Kersanton granite, and one that will defy the corrosions of the land of saline mists. It rests upon a colossal base 40 feet square and 40 in height, ornamented with fascia and handsome mouldings. Over the front door will be read, in large letters, the inscription:

PHARE D'ECKMUHL—1893.

The machicolated cornice of the summit, which is surrounded by an elegant granite parapet, is reached through an interminable interior spiral of two hundred and fifty-seven stone steps. Although the ascent is somewhat tiresome, it is worthy of being made. In the first place, one can here admire at his ease two magnificent works of art, viz., the bronze staircase, which cost nearly $16,000, and the ornamentation of the walls, which are covered with superb slabs of opal, the whole valued at $5,000. Then the splendid and ex-

tensive view of the Brittany coast obtained from this granite belvedere will further repay the tourist.

Here, at a hundred and fifty feet above the waves, is the saloon of honor of the lighthouse—an octagonal room provided with eight windows, four of which are closed with beveled glass, in which is placed a reduction of the statue of Marshal Davout, Prince of Eckmühl, that ornaments one of the squares of Auxerre. At the side there is a list of the battles in which the marshal engaged, and a commemorative inscription upon a marble tablet. Alongside of the saloon of honor, and upon the same platform, is the metallic room containing the fog horn. This powerful apparatus will be heard at a great distance, since the intensity of the tones produced should correspond to a motive work of about 100 horse power. From the platform, an iron stairway leads to the lantern, the focal plane of which is at 196 feet above the level of high water. It is crowned with an elegant cupola ornamented with a wind rose and provided with a lightning protector. It is here that will be permanently installed the two improved lanterns, which will project over the waves an intense light, that may be raised to three million six hundred thousand Carcel burners, or nearly forty million candles, so that it may be seen at a distance of more than sixty miles.

The hydrographic service of the navy has already made known to all the ports of the coast and to navigators that this new and powerful electric light has been in operation since the night of October 17, the day of its inauguration, and that it gives regular white flashes which succeed one another every five seconds. At the base of the lighthouse are situated the quarters of the keepers and mechanicians, and two structures set apart for the machinery.

This electric lighthouse, which will have no rival in the entire world, is the work of Engineers Bernard, Bourdelle and Considère. The principal director of the work was M. Probestan, of Brest.—Le Monde Illustré.

ACETYLENE AS AN ILLUMINANT.

OUR readers have always been kept informed by us as to the progress of the acetylene industry, which is due to the researches of M. Moissan upon the electric furnace. We have, however, observed the greatest prudence in regard to the practical side of the question. Can this wonderful gas, about which as much bad as good has been said, be recommended without danger? Is it poisonous, or is it explosive, as has been asserted?

Some accidents that happened at the outset seemed to decide in favor of its detractors, and there are still many persons who do not speak of acetylene without secret dread. It has been our desire to allow experiment to have time to accumulate proofs, and we can now, at least, speak from experience and say that, rationally employed, acetylene is less dangerous than coal gas.

In effect, the labors of MM. Brociner, Gréhant, Le Chatelier, Vieille and Berthelot have proved the following facts:

A mixture of air and acetylene, in order to become dangerous to breathe, must contain a very large proportion of the latter gas (say about 40 per cent.), while a much smaller proportion of coal gas, which contains carbonic oxide, suffices to cause asphyxia. Such a mixture can explode only through ignition, and only when it contains, at the least, 5 per cent., and, at the most, 25 per cent. of acetylene. Finally, acetylene alone, unmixed with oxygen, cannot explode unless it is compressed to about two atmospheres or upward.*

Now, in the ordinary apparatus, acetylene is utilized under a pressure of a few fractions of an inch solely. Mixtures of air can take place only in very feeble proportions, since the volume of acetylene that can be disengaged is limited by the weight of the carbide contained in the generating apparatus. An apparatus that contains, say, 10 pounds of carbide is capable of producing about 55 cubic feet of gas. If, in consequence of an accident that causes a leakage of gas, or of some act of carelessness, such as leaving a cock or an unlighted burner open, all the gas be disengaged in a room of small dimensions, say of about 1,800 cubic feet, the 55 cubic feet of gas will form a mixture of about 3 per cent., that is to say, not dangerous.

These conditions are much more favorable than those which result from the use of coal gas, since the latter may become distributed through the atmosphere in indefinite quantity, and, in consequence of its feeble density, tend to form a highly dangerous mixture in the upper part of a room.

Moreover, it is proved by experience that all the accidents that have occurred have been due to carelessness. These happen every day from the same cause with gas, kerosene, alcohol and gasoline, and yet we do not condemn the latter, but merely handle them with more caution (at least for a few days)—that is all. It will be the same with acetylene.

There now exists in France a large number of applications of the new gas. We might mention several that are found in Paris. In the outskirts of this city we meet with them in the Maimaison Park, at Raincy, Arcueil-Cachan, etc., and in the country at the sanatorium of Kerlanny. The city of Crémieux (Isère) is wholly lighted by acetylene, as is also the bathing station of Ussat-les-Bains. These are merely a few examples selected from among several hundred. All the owners of these installations are fully satisfied with the service obtained, and no accident has occurred, although the maneuvering of the apparatus is intrusted to domestics or to any sort of employe whatever.

The practical period is therefore open, and it may be hoped that the new industry will take on a rapid development that shall, up to a certain point, justify the enthusiasm of inventors. Since the Bullier patent was taken out on the 23d of January, 1895, up to the present, nearly three hundred inventors, in France alone, have devised and patented acetylene apparatus. It is unnecessary to say that we have no intention of describing all of these. Many of them, moreover, are merely copies of their predecessors. We shall be content to explain the different principles that have been brought into play, in describing, by way of example, a typical apparatus of each kind.

* We except acetylene dissolved in acetone (Claude & Hess process). By this process, for which we think there is a great future in store, the compression can be carried to a very high figure without any danger of explosion.

It is well known that, in order to produce acetylene, it suffices to put water and calcium carbide in contact. This operation can be performed in three different ways:

(1) According to the principle of the hydrogen lighter.

(2) In allowing water to fall upon the carbide in excess; and

(3) In causing the carbide to fall into an excess of water. Hence there are three distinct classes of apparatus.

On another hand, in order that an acetylene generator shall give entire satisfaction, it must produce the gas at the very moment of consumption, and in a quantity equal to the volume discharged by the apparatus of utilization, without producing an excess of gas to diffuse itself in the air, and the heat engendered

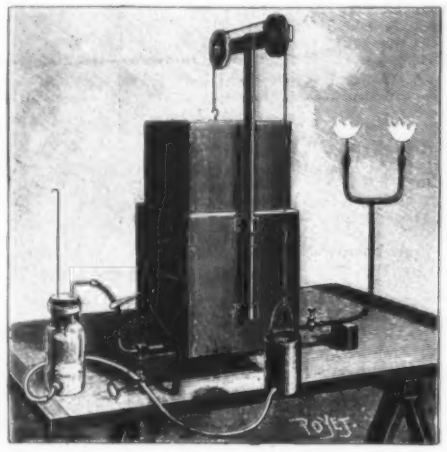


FIG. 1.—THE O'CONOR SLOANE ACETYLENE GAS GENERATOR FOR AMATEURS.

by the reaction must be sufficiently dissipated to prevent a notable elevation of temperature, which might affect the purity of the gas and interfere with the regularity of its production. Finally, the cleaning, maintenance, and recharging with water and carbide should require nothing more than the maneuvering of simple parts, such as cocks or slide valves, in as small number as possible in order to prevent false maneuvers and avoid the removal of any piece capable of allowing the escape of acetylene into the air.

The second condition can be satisfied only by decomposing the carbide in the presence of an excess of water. In the apparatus in which the water falls drop by drop upon an excess of carbide, the temperature may reach several hundred degrees, and the gas disengaged is very impure.

The first condition is quite difficult to realize in the apparatus of the two first classes, for the following reasons: The carbide is first attacked upon the surface, which becomes converted into lime that must afterward be wet before the lower strata of carbide are attacked. As the reaction produces heat, and as the lime, at about 50°, absorbs nearly three times its bulk of water, it results that, at every operation, much more water than is really necessary must be admitted. Since, on another hand, the carbide has a very great affinity for water, it afterward gradually absorbs all of this liquid that the lime is saturated with, and thus continues to become decomposed and to disengage gas, even when the apparatus is not in operation. In reality, every fragment of carbide of the weight of those that are employed in gas generators, once wet, becomes entirely decomposed. The bulk of the carbide placed in contact with the water at every moment must be limited. The smaller it is, the more it will avail. So inventors, instead of leaving all the carbide that the apparatus contains in a single block, arrange it in small separate receptacles placed either alongside of one another (Bon apparatus, Fig. 2), or one above the other (Deroy apparatus, Fig. 3). The water can enter but one compartment at a time, and the quantity of carbide wet is thus limited.

The method of attack of the carbide that we have just explained is followed by still other unfavorable consequences. A certain amount of time elapses between the moment at which the water is admitted and that at which the carbide begins to be attacked, since the lime must first be wet. Afterward, as the decomposition of a fragment occurs by successive strata, the time consumed is very appreciable.

Since the entrance of the water is regulated by the volume of the gas disengaged, it results that it is admitted for a period longer than is necessary, and this is followed by an over-production. The regulation of the entrance of the water is, therefore, a matter of prime importance.

In the apparatus of the first class, since the pressure of the gas acts upon the entire mass of the water and over a very wide surface, there often occur considerable changes of level, and, consequently, continual over-productions. So no generator of this kind has given very good results, and we shall therefore pass such apparatus by.

The apparatus of the second class may be arranged in three distinct categories:

(1) The first category includes those in which the receiver of the gasometer, in rising or descending, carries along the water reservoir or the carbide receptacle, and thus puts the two substances in contact. Dr. O'Conor Sloane's apparatus (Fig. 1) is the type of these. It will be understood at a glance. The drawbacks to this mode of regulation are the same as those that accompany the apparatus of the first class, the bulk of water brought into play being too great.

(2) The second category embraces those apparatus in which the entrance of the water is rendered regular by a cock which the receiver of the gasometer opens in descending below a certain level and closes in ascending. Such apparatus are those of Dickerson, Janson & Leroy, Sourlou, Clausolles, Rosenberg, Bon and others. Fig. 2 represents the Bon apparatus, which is well elaborated.

The water, which is contained in C, flows through the tube, G, upon which is mounted the regulating cock, r, operated automatically by the receiver, B, through a lever, l. The carbide is contained in a box, A, divided into compartments and placed in the receptacle, E. The water always falls over the same compartment, which it gradually fills, and then overflows into the following compartment through an aperture at the top of the partition. After it has filled this, it overflows into the next, and so on. The weight of carbide contained in each compartment is sufficient to fill the receiver, B, with gas without any surplus. The box, A, after being placed in E, is held by a lever, P. The holder and receiver are assembled by a hydraulic joint, in order to prevent leakages of gas. The tube, G i, is bent twice for the same purpose.

The regulation by cock gives good results when the discharge of the utilizing apparatus is feeble with respect to the capacity of the generator. The height of the receiver varies slightly beyond or within the point corresponding to the limit between the opening and closing of the cock. As soon as the receiver descends slightly, the cock allows a few drops of water to pass; then the receiver rises and closes the cock. In this way there is obtained a very regular production of gas. But, if the discharge becomes very great, and if it is intermittent, the production ceases to be regular, because the holder of the gasometer tends to remain toward the bottom of its travel, and, under such circumstances, since the cock is too wide open, the regulation becomes inadequate.

When the receptacle, E, is removed in order to clean the apparatus, the gas that it contains escapes into the atmosphere, and care must be taken to close the cock,

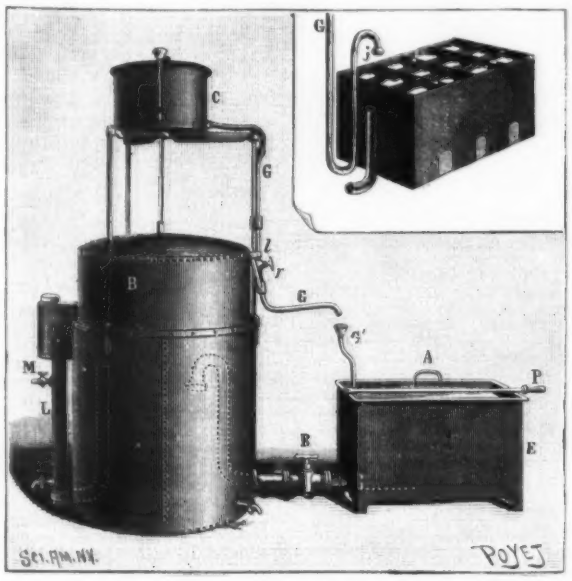


FIG. 2.—THE BON ACETYLENE GENERATOR.

B, in order to prevent accidents. The apparatus is provided with but one generator, and this necessitates recharging as soon as the carbide is exhausted, even in the middle of the evening.

(3) The third category contains those apparatus in which the entrance of the water is regulated by a play of equilibrium between the pressure of the gas and the weight of a column of water of determinate height. This is the most perfect method of regulation. The Exley, Ackermann and Deroy apparatus are based upon this principle. The one best elaborated is that of Deroy (Fig. 3).

The water contained in a reservoir, A, supplies a constant level receptacle through an arrangement analogous to that employed in the watering troughs of poultry yards. Thence it flows through the tube, t, to the cock, R, which permits of sending it to one or

the other of the generators, 1 and 2. Let us suppose that it is sent to the former:

It follows the tube, t', and falls to the bottom of cylinder 1, which contains the carbide receptacle, divided into superposed compartments, as shown in the figure. The water gradually rises in the cylinder and wets the carbide. The gas that is disengaged passes through N', the bent tube, J, and the purifier, L, partly filled with water, before flowing to the gasometer. After a sufficient quantity of gas has been produced to make its pressure equal to or exceed that resulting from the weight of the column of water between the constant level receptacle and the cock, R, the water is forced back and the production ceases automatically, and is not resumed until the volume of gas stored up diminishes as a consequence of the consumption of it. The water thus gradually rises in 1 and successively decomposes all the carbide. After this result has been attained, it reaches the level of the tube, t^2, flows through it, reaches the part, N^2, and falls into the generator, 2, where the same succession of operations takes place. A continuous production of gas is thus obtained automatically, without the necessity of turning a single cock.

The use of two generators permits of effecting the cleaning and recharging at the most opportune moment. This operation is performed without the possibility of any disengagement of gas occurring, since the generator is completely filled with water, and tubes, t^3 and J, form perfect hydraulic joints. This latter arrangement, which is characteristic of the Deroy apparatus, is very interesting. The regulation of the water is sufficiently perfect to allow one, with the same apparatus, to supply a very variable number of burners, and to extinguish all of them simultaneously, without an overflow of gas from the holder.

In order to prevent any danger of over-production, the inventor has adopted a very simple and efficient arrangement. At a slight height above the normal position of the holder, he suspends a weight, P, which the holder raises in ascending, and which is sufficient to increase the pressure of the gas by about one-half an inch of water in the interior of the gasometer. In this way, the equilibrium that regulates the entrance of the water is broken and the production of the gas is prevented as long as the interior pressure of the gas has not diminished, that is to say, as long as the holder, in descending, has not abandoned the supercharge.

This apparatus very completely answers the requirements that we have outlined above.

We are indebted to La Nature for the cuts and copy.

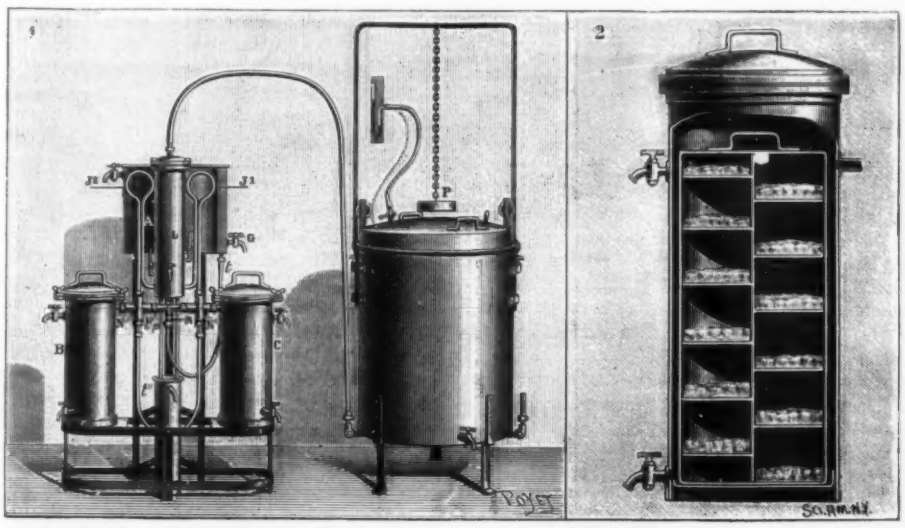


FIG. 3.—THE DEROY ACETYLENE GENERATOR.

SOME NOTES ON POTTERY.

AVENTURIN GLAZES.—L. Petrik, of Buda-Pesth, has succeeded, according to a paper contributed to the Deutsche Chemische Zeitung, in preparing artificial crystalline ferric oxide by fusing dehydrated green vitriol and common salt, and extracting the mass with water. The crystals dissolve with difficulty in fused glazes and produce on pottery the Aventurin glaze of the Rookwood Pottery Company. When added in large quantity to normal stoneware glaze, the crystalline oxide renders the latter more refractory and deprives it of luster. It is more readily soluble in the light lead glazes, and imparts thereto the handsome warm tone characteristic of American Aventurin ware. Petrik applies two coatings of glaze; first stoneware glaze mixed with the oxide, and then brings out the luster and transparency by a cover of fusible, transparent, yellow brown lead glaze. The same investigator has also prepared crystalline chromic oxide by fusing potassium bichromate with common salt, and has produced therefrom an imitation of chrome Aventurin; but since the chromic oxide dissolves in lead glazes and oxidizes to chromic acid, he has adopted an alternative method for the production of chrome Aventurin by coating the iron oxide glaze mentioned above with a green lead glaze containing copper.

PRACTICAL METHOD OF REPRODUCING MONOCHROME PICTURES ON POTTERY, ETC.—Our contemporary Diamant describes the following process for reproducing prints on glass or porcelain in monochrome without the aid of photography, the only essential points being that the original shall be well printed in line work or autotype, on absorbent paper of fair quality, lithographs, copper or steel engravings and typographs (bookwork) being all suitable, provided the ink is good and of sufficient covering power to print large surfaces and letters without leaving any blank spots. The first step is to thoroughly damp the paper by applying water to the back (which must not be printed) until the surface appears regularly moistened without exhibiting any specks. This will be effected in the course of a few minutes, and the print will then be ready for the next stage. It should, however, be first mentioned that in old prints the oil contained in the printer's ink having become resinified by long exposure to the air, has lost to a great extent its fatty nature. Such prints, therefore, require to be revivified by an application of chloroform at this stage, and, indeed, improved results will be obtained by the use of this liquid in nearly every case. The second step in the process is to reproduce the design in relief on gelatine. With this end in view a film of gelatine is laid on a thick sheet of glass or metal, and on this the damp print is placed face downward. This in turn is covered with a sheet of moistened blotting paper, followed by a second plate of glass or metal, the whole being placed in a screw press for one to four minutes under moderate pressure. For experimental purposes an ordinary letter-copying press will do, but a more accurately adjusted apparatus will be required for actual working operations. The gelatine will absorb water from the surface of the print, except where the latter is covered with ink, and by swelling up will give a relief counterpart of the design or picture. An excess of moisture or pressure will detract from the accuracy and clearness of the relief. Before the crevices on the gelatine have become too dry to retain the coloring matter, the dry pigment is dusted in by means of a fine brush. If the right degree of moisture has been employed in the earlier stages, the color may be applied almost immediately. Where the gelatine is too damp it will be possible, with a little practice, to hit on the precise moment, after five or ten minutes' standing, when it has dried sufficiently to be an accurate reproduction of the original, whereupon the color may be dusted on. As soon as the gelatine film is thoroughly dry, the surface is covered with a layer of collodion, which will seize upon the dry color, so that when the ether has evaporated the gelatine can be removed by dissolving in lukewarm water without injury to the sharpness of the design. The final stages of applying the picture to the surface of the ware and firing are performed in precisely the same manner as in photoceramic work.

IMPROVED METHOD OF APPLYING TRANSFER PICTURES TO POTTERY, ETC.—A recent German patent dealing with the above named object claims that better results can be obtained by using dilute oil of cloves for removing the cover of the transfer than by the ordinary method in which water is employed. The use of clove oil in porcelain painting is well known, and its advantage in the present case is based on the same properties which render it valuable in the latter industry, viz., that it dissolves the pigments and retains them in their original position until fixed on the ware by firing. However, the amount of oil required to loosen the cover is far in excess of the quantity necessary, or, indeed, advisable, for dissolving the color, the surplus tending to form a layer between the body and the color, so that dilution of the oil is necessary. To this end one part of clove oil is mixed with forty parts of five per cent. carbolic acid solution—this being found the most satisfactory diluent obtainable—at a fairly high temperature. The picture being applied to the ware, the surface of which is preferably covered with some adhesive lac, the back is brushed over with the diluted oil; in a short time the paper cover can be drawn off, and the piece is ready for immediate firing.

MANUFACTURE OF OPTICAL GLASS IN GERMANY.—The method employed in the works of the Schott Company, at Jena, consists in heating the dry crucible gradually for four or five days until bright red heat is attained, whereupon it is transferred to the melting furnace, and when the fusing temperature is reached the crucible is glazed inside by introducing a few fragments of glass, and is then filled with the raw material. When fused, the mass is kept at a high temperature for about a week, and is then examined by drawing a small sample by means of a tube. If found free from air bubbles and impurities, the crucible is placed in the open air for half an hour or so to cool and afterward left in a cooling kiln for three days. The glass splits into several pieces, and these, after being broken up small, are placed in moulds, which are then heated to the point of incipient fusion and gradually recooled, the operation lasting some ten or twelve days. Both faces of the moulded glass are polished in order to discover the existence of any faults. When the sound plates form 20 per cent. of the original weight of material, the result is considered satisfactory. Many prisms and lenses are cast in moulds to save time in shaping, and the object glasses of telescopes are treated with more than ordinary care to obviate any irregularity in the cooling and reheating processes.—Monit. de la Ceramique.

IRREGULARITIES IN STONEWARE GLAZE.—It frequently happens that stoneware glaze, instead of being evenly distributed over the entire surface, recedes from some parts to accumulate in others, thus giving the ware—especially in the case of colored glaze—a streaky and irregular appearance, and so leading to its condemnation. The immediate cause of this phenomenon is the non-absorption of the glaze by the biscuit, which may, however, be ultimately traced to the ware, the coloring matter, or the glaze. In the former case overfiring reduces the porosity and absorptive power of the surface, and the same result will be produced if dust be allowed to accumulate and stop up the pores, or if any portion becomes damp or greasy from any cause. This may be easily demonstrated by sprinkling a piece of stoneware with water and then applying and firing the glaze, when the latter will be found to have retreated from the damp patches and become piled up in the dry places. The nature and condition of the underglaze pigments also contribute to uneven glazing, the finely divided coloring matter stopping up the pores of the ware to a greater or smaller extent, the alumina colors being, on account of their slimy nature, particularly to blame in this connection. The other underglaze colors also contribute to the same end by their indisposition to fuse along with the cover glaze. When the fault is due to the glaze itself, several circumstances may assist thereto, chief among them being excessive fineness in the grinding, which results in the individual particles having a greater cohesive force than the absorptive action of the ware surface can overcome. A second cause is the use of hard glazes, particularly such as have been fritted as a whole, but received, for grinding, additions of dry, stony materials only. The thickness of the applied layer of glaze will affect the distributing properties; the thinner it is laid on, the better. The remedies vary with the cause. In the first place the overfiring of the unglazed ware must be avoided. Then it will be necessary to dust the pieces with great care, and to see that they do not get contaminated by grease, oil, etc., from the hands or other source. So far as the glaze itself is concerned, the chief thing to avoid is overgrinding. To control this, the time occupied in grinding a successful glaze should be noted and adhered to in subsequent preparations of the same kind. Underglaze colors should be mixed with a determined percentage of fusible glaze to facilitate their adhesion to the body. The distributing power of the hard glazes may be increased by means of a larger proportion of lead; where this cannot be given, they should be replaced by others needing no such admixture. Boric acid will also increase the distribution of the fused glaze. Finally, the glaze must be applied in layers of normal thickness.—Sprech-Saal.

CHANGE IN THE HABITS OF WILD ANIMALS OWING TO THE ADVANCE OF CIVILIZED MAN.

THE notoriety gained some years back by the New Zealand "kea," which, from being a "farmer's friend," developed into one of his most dreaded enemies, through the acquired taste of the huge cockatoo for the kidney fat of living sheep, is paralleled in many other instances in our colonies. In a recent note in The Zoologist, Dr. Schonland relates how the chacma baboon has now become a regular scourge in some parts of Cape Colony, for an unexpected reason. It is perfectly notorious that it has largely taken to killing lambs, for the purpose chiefly of sucking the milk with which they have filled their stomachs. The reason that it has, if anything, increased in the colony during recent years is twofold. First, the alarming spread of the prickly pear (Opuntia sp.) in some districts has provided it with almost impenetrable shelter and abundant food, as it is fond of the fruit and also eats the leaves. Secondly, it has become so cunning that only by means of artful maneuvers can one get a shot at it. A friend of the writer, whose wife could approach a troop of baboons without disturbing them, borrowed, one day, her cloak and hat, and then went out. They let him approach to very close quarters, and two of them were shot before the remainder got into shelter. Sometimes the farmers of a district combine, and during the night surround their sleeping place. As soon as the day breaks and the baboons try to escape they are shot down in large numbers, but this method of reducing their ranks is not always practicable. The baboon is not the only South African animal which has during recent times changed its habits. Thus the so-called "wet-gat spreouw" (Spreo bicolor) was formerly never known to touch fruit, its food consisting chiefly of insects, but during recent years it has, at all events on some farms with which Dr. Schonland is acquainted, become very destructive to fruit. Another case which possibly comes under the same category is that of the Maanhaar jackal, Proteles cristatus. The Cape government was paying a high reward for this animal, because it was supposed to be destructive to small stock. Dr. Schonland protested against this, as in his experience nothing but insects had been found in the stomachs of these animals. He was astonished to find this statement was met with a howl of indignation proceeding from farmers living in other districts, who were positive that this animal was a dangerous enemy to their flocks; and if they are correct, the Maanhaar jackal must have changed its habits during recent years and in certain districts only, when possibly with the advance of civilization its natural food is failing.

Dr. B. Kossmann, of Charlottenburg, Germany, has secured a patent from the imperial government covering a rust-preventing paint composed of the peroxides of earths of the cerium group. The oxides in question are incorporated with linseed oil varnish, to which is added as a drier a portion of linseed oil boiled with a mixture of boric acid and the peroxides. The resulting paint can be colored with graphite, lampblack, heavy spar, etc., and is said to fulfill all the requirements exacted of such a composition, a sufficient oxygen content to insure the resinification of the linseed varnish and freedom from any metallic base capable of setting up an electrical action with iron and so causing the formation of rust.

GLIDING EXPERIMENTS.*

MR. CHANUTE stated in beginning that when, in 1891, Prof. Langley, the eminent astronomer, and the secretary of the Smithsonian Institution, published his important work, "Experiments in Aerodynamics," the closing paragraph of the summary was as follows: "I wish, however, to put on record my belief that the time has come for these questions (i. e., those of aerodynamics and aerial navigation) to engage the serious attention, not only of engineers, but of all interested in the possibly near practical solution of a problem, one of the most important in its consequences of any which has ever presented itself in mechanics; for this solution, it is here shown, cannot longer be considered beyond our capacity to reach."

Mr. Chanute continued that it did not seem to the general public then, and it possibly might not seem now, as if a commercial and practical flying machine was an achievement to be expected in the near future; yet it did seem opportune for an engineer approaching the end of his professional career to devote some of his leisure to the investigation of the laws which must be hereafter observed by other engineers in compassing the navigation of the air. He therefore took up the question; and believing that the surest method is first to study past failures in a novel undertaking, he made an investigation of the records of all the experiments which had been tried during the last two or three hundred years in the endeavor to imitate the birds. This resulted in a number of technical articles which swelled into a book, in which the attempt was made to eliminate the causes of each failure; for up to that time there had been nothing but failures.

He said he had hitherto abstained from addressing his fellow engineers on the subject, as some might deem it premature, but he had become gradually convinced, not only through investigation, but through practical experiment, that it was not only possible but almost certain that man will eventually be enabled to make his way through and on the air by dynamic means, although it might require a considerable and long process of evolution to do so. This evolution was now in progress, and very great advance has recently been accomplished. It chanced that about the year 1888 a number of able men, in various parts of the world, simultaneously took up the question, and the progress which they have made is already greater than that previously achieved during the past two or three centuries. Those men were Mr. Maxim, an American in England, Prof. Langley in this country, Mr. Hargrave in New South Wales, and Mr. Lilienthal in Germany. They investigated afresh the laws which underlie the possible solution of the problem of flight, and the results of their labors will probably best appear from a discussion of the various elements of that problem.

These elements number ten at least, and may be considered as so many subsidiary problems, each to be solved separately, perhaps in more ways than one, and those solutions then to be combined into a harmonious whole. They may be stated as follows:

1. THE SUPPORTING POWER AND RESISTANCE OF AIR.

This first problem is the foundation of the whole subject, and, singularly enough, it is only within the last six years that it has been settled beyond question what is the true measure of those properties of air when meeting a surface at an oblique angle of incidence. Sir Isaac Newton gave by implication from his Proposition XXXIV, Book 2 of the Principia, a law which has variously been interpreted as meaning that normal fluid pressures vary as the sine or the square of the sine of oblique incidence. These formulas are today still taught in the schools, and found in text books, although experiments have shown that at very acute angles they give from one-tenth to one-twentieth of the true results. Engineers make current use of them in calculating pressures upon roofs, and upon parts of bridges struck obliquely by the wind, while with later knowledge it can be shown that a wind gust deflected upward under the floor of a bridge, even so little as 5 or 10 degrees, produces such a lifting effect as to account for the blowing off of superstructures hitherto accounted as inexplicable. In point of fact, Prof. Langley's experiments showed that oblique air pressures varied not as the sine or the square of the sine of incidence, but approximately as indicated in the empirical formula proposed by Col. Duchemin about 1828, in which the relation between the rectangular normal pressure and the oblique normal pressure is represented by:

$$P = P' \times \frac{2 \text{ Sine } a}{1 + \text{Sine}^2 a}$$

In which P = the oblique pressure.
P' = The rectangular pressure.
a = The angle of incidence.

This applies exclusively to planes or flat surfaces, while Lilienthal has shown by experiment that curved surfaces presented with their concave side to the wind afford still greater pressures, these being from twelve times to four times the normal pressures obtaining upon planes at angles between 1 and 5 degrees, which are those most favorable for flight. Thus it is that we are now enabled to calculate with some confidence the support which may be obtained by gliding at any given speed upon the air, and the power required to overcome the resistance. An eminent French mathematician, at the beginning of this century, calculated that a swallow, weighing six-tenths ounce, expended in full flight no less than one-thirteenth of a horse power. This calculation was evidently erroneous. It would have implied that the weight of a man, say 150 pounds, would require the expenditure of something like 300 horse power to sustain it in the air, but calculations of the power really required could not be made with confidence until the recent labors of Prof. Langley, confirmed as they have been by those of Mr. Maxim, and the still more encouraging coefficients for concave surfaces obtained by Lilienthal and in the experiments which were to be presently described.

2. THE MOTOR, ITS CHARACTER AND ITS ENERGY.

This second problem, now nearly solved, was thought until five years ago to be still more difficult than the obtaining of supporting power from the air. It was known that the motor muscles of birds, though possessing but little more tensile strength than those of land animals, gave out energy at a much more rapid rate, so that it was variously estimated that bird machinery (muscles) weighed from 5 to 20 pounds for one horse power exerted. Upon investigation in 1890 it was found that the lightest steam engines then in use were those in launches and weighed 60 pounds per horse power, that the lightest petroleum engines weighed 88 pounds per horse power, while the lightest electric motor weighed 130 pounds, and the lightest storage battery and dynamo weighed some 200 pounds per horse power hour. Since then the advance has been very great. Mr. Maxim has produced a steam plant of 360 horse power which weighs about 8 pounds per horse power. Prof. Langley has built an engine and boiler which weighs 7 pounds and exerts one horse power, while Mr. Hargrave has constructed a steam engine weighing about 10 pounds to the horse power. Almost as great advances have been accomplished with petroleum motors, which possess the great merit of dispensing with a boiler, so that for the first time the realization of a sufficiently light motor for a dynamic flying machine seems to be within sight. It now seems probable that this will be accomplished with a petroleum engine when the eccentricities now inherent to that class of unperfected motors have been overcome in practice.

FIG. 1.—MODIFIED LILIENTHAL MACHINE.

FIG. 3.—FIRST FORM MULTIPLE-WING MACHINE.

FIG. 2.—LILIENTHAL TYPE UNDER WAY.

FIG. 4.—SIXTH FORM MULTIPLE-WING MACHINE.

3. THE INSTRUMENT FOR OBTAINING PROPULSION.

The third question relates to the device through which adequate thrust shall be obtained by action upon the air. All sorts of contrivances have been proposed: reaction jets of steam or of compressed air, the explosion of gunpowder or even nitro-glycerine, feathering paddle wheels of varied design, oscillating fins acting like the tails of fishes, flapping elastic wings like the pinions of birds, and the rotating screw. Mr. Maxim and Prof. Langley have made many experiments to determine the best form, speed and pitch of the screw to obtain thrust from the air, and have materially improved that instrument, which, to reason from analogy in land and water transportation, seems likely to prove the best device; but both Mr. Hargrave and Mr. Lilienthal have obtained very favorable results with the flapping pinion, which requires no intervening machinery to change the reciprocating action of a piston into a rotary motion, and it seems perhaps possible that success in artificial flight may be obtained with either or both devices.

4. THE FORM AND KIND OF THE APPARATUS.

This fourth question has elicited great divergence of views among the designers of flying machines. Almost numberless projects have been advanced, but they can all be classified under three heads: 1st, wings to

* An address by Octave Chanute, C.E., Mem. W. S. E., delivered before the Western Society of Engineers, October 20, 1897, and published in the Journal of the Society.

sustain and propel; 2d, rotating screws to lift and propel; and, 3d, aeroplanes or aerocurves, to consist of fixed surfaces driven by some kind of propelling instrument. The first two have been the first to be proposed and experimented with. They have many warm advocates at the present time, but the practical experiments made within the last five years seem to indicate that success will first be achieved with aeroplanes, or to state it more accurately, by coining a new word, with aerocurves, which have been shown by Lilienthal to furnish much greater lifting reactions. The following table, in which the weight of the operator of a one-man machine is included with the weight of the apparatus, approximately indicates the comparative merit which our present knowledge enables us to assign theoretically to these three varieties of flying machines.

Comparative efficiency of various forms.

Kind of apparatus.	Pounds probably sustained per horse power.	Proportion probably available for motor.	Resulting possible weight of motor per horse power.
Screws.....	25	17 per cent.	4 pounds.
Wings.....	80	10 "	8 "
Aerocurves...	80	17 "	14 "

It will be noticed that this involves motors which shall be very light in proportion to their output of energy, and that the fuel and other supplies must also be included in the weights above given, but yet that the desired results for aerocurves at least are now almost in sight.

5. THE EXTENT OF THE SUSTAINING SURFACES.

The fifth problem, relating to the extent of surface required to support the weight of a man, has caused in the past active controversy and gathering of data. It was perceived that in consequence of the law inherent to solids, the surfaces will increase as the squares, and the weights as the cubes of the homologous dimensions; it might well be that the additional relative weight due to the greater leverage should make it impossible to compass any larger flying machine than existing pushed much, if at all, beyond 100 pounds of machine and operator together.

In point of fact, flying creatures vary in extent of supporting surface from about 40 square feet to the pound in the butterfly to an area of 44-100 square feet to the pound in the duck. The amount required depends upon the speed of the creature's flight, the larger soaring birds generally spreading about one square foot or less to the pound, while the experiments of Lilienthal, as well as those to be hereafter described, have demonstrated that a man's weight can be well sustained at 22 to 25 miles an hour by an apparatus spreading three-quarters of a square foot to the pound, and that this apparatus need not weigh more than from 23 to 36 pounds, without motor or propeller, so that if the latter weigh some 60 pounds more, we may fairly expect to compass a dynamic machine with a weight of about 100 pounds, carrying a man of about 150 pounds, upon sustaining surfaces of rather less than 200 square feet in area.

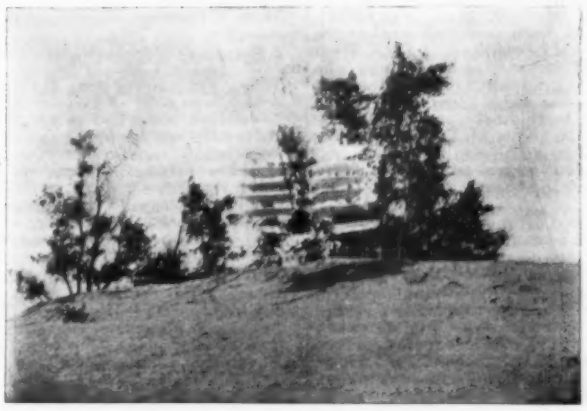


FIG. 5.—FRONT VIEW MULTIPLE-WING MACHINE IN FLIGHT.

6. THE MATERIAL AND TEXTURE OF THE APPARATUS.

The sixth question relates to the material to be selected for the framing of the machine, for the motor, and to the texture of the sustaining surfaces. Nature accomplishes her purposes with bone, flesh and feathers, but man has at his command metals, fuel and textile fabrics. Many hopes were expressed some years ago, when aluminum first became a commercial metal, that it was about to solve the problem of aerial navigation. Later investigations have developed the fact that aluminum is as yet inferior to steel per unit of weight. It is lighter, but it is also weaker. For a beginning wood will do very well. It is a fact, realized by few engineers, that the best woods, so long as they remain undecayed, are actually stronger in proportion to their weight than the ordinary grades of steel. Wood is easily and cheaply procured and shaped, and whatever success has hitherto been had in gliding flight has been accomplished with wooden frames covered with textile fabrics. The latter are probably inferior in efficiency to the ribbed surface of feathers, as quite recent experiments tend to show, but they will answer for a beginning.

Thus we see that six out of the ten subsidiary problems involved in the general question have been approximately solved. Not all, but most of this has been accomplished within the last few years. The remaining four problems are more difficult of solution, but even toward this, gratifying advance has been made.

7. THE MAINTENANCE OF THE EQUILIBRIUM.

The seventh problem relates to the stability of the apparatus in the air, and especially in a wind. This equilibrium must be maintained at all angles of incidence and under all conditions of flight and of wind, in rising, in sailing and in coming down. The first requisite for this is that the center of gravity shall constantly be in a vertical line with the center of pressure, and unfortunately the latter is almost constantly varying with the relative wind, with the speed and with the angle of incidence. It is a peculiarity of air pressures, ascertained by experiment, that as the angle of incidence changes, the position of the resultant center of pressure also changes. When air meets a surface at right angles, the center of pressure coincides with the center of that surface, but when the angle becomes more acute, the center of pressure moves forward until it approaches a position about one-fifth of the distance back of the front edge on a plane. This movement is approximately expressed by what is known as Joessel's formula for square planes:

$$C = (0{\cdot}2 + 0{\cdot}3 \sin a)\, L$$

In which C = The distance from the front edge.
L = The whole length fore and aft.
a = The angle of incidence.

This formula is found not to be accurate for oblong planes, and even not strictly true for square planes, but it is understood that recent experiments are likely to produce a more accurate formula for planes. The great need, however, is for a formula which shall accurately express the movements of the center of pressure on concavo-convex surfaces. They are known to present some curious anomalies, but no physicist, so far as is known, has yet reduced them to the reign of law. The problem of stability may be said to have been very considerably advanced. The experiments hereinafter to be described were undertaken with the sole view of evolving the solution of this question, for it is held to be of the very first importance. Far more so than seems to be realized by experimenters; for until automatic equilibrium is secured and safety is insured thereby, under all circumstances, it will be exceedingly dangerous to proceed to apply a motor and a propeller. Birds preserve their balance by instinct, by skill acquired through long evolution and tentative practice. Man will have to work out this problem thoroughly, even to the temporary disregard of the others, if he is ever to make his way safely upon the air.

8. THE GUIDANCE IN ANY DESIRED DIRECTION.

The eighth problem relates to the steering. It has been generally supposed that this would be best effected by horizontal and vertical rudders, but the experiments of Lilienthal, and those to be here described, have shown that slight changes in the position of the center of gravity are more immediate and effective. This problem cannot be said to be fully worked out, but it is not deemed to be very arduous. We already know that a gliding machine is exceedingly sensitive to the least change in the position of the weight or of the rudders, and therefore that it will be easily controlled by slight movements, if they are accurately made.

9. THE STARTING UP UNDER ALL CONDITIONS.

The solution of the ninth question, as to the best methods of starting away from the ground, is likely to be one of the last to be practically worked out. It will require a great deal of experimenting and ingenuity to devise means for rising from a level under all conditions. This is a task for the future. Meanwhile it is easy by special appliances, or by starting from an eminence in the wind, to get a machine into the air so as to work out the more immediate problem of stability.

10. THE ALIGHTING SAFELY ANYWHERE.

The tenth problem relates to the alighting. It is the one which always produces a smile upon its bare enunciation, probably in remembrance of that little experiment of Darius Green. It may be said to be as yet unsolved for the dynamic machine of the future, and yet both Lilienthal's experiments and those to be now described showed this problem to be very easy of solu-

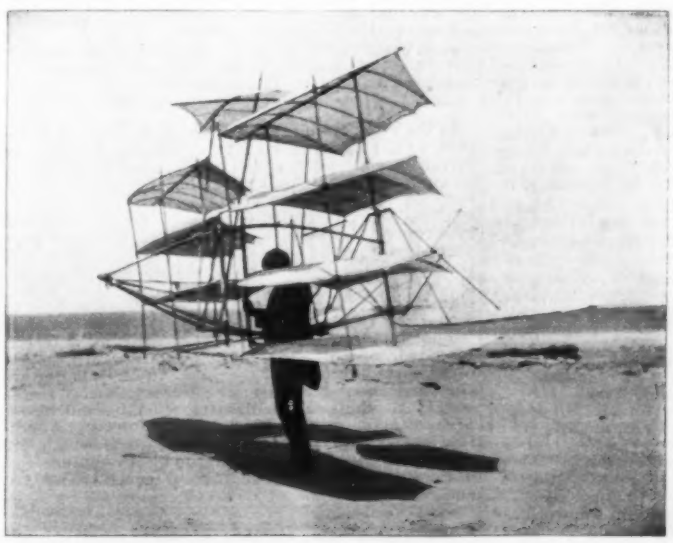


FIG. 6.—SEVENTH FORM MULTIPLE-WING MACHINE.

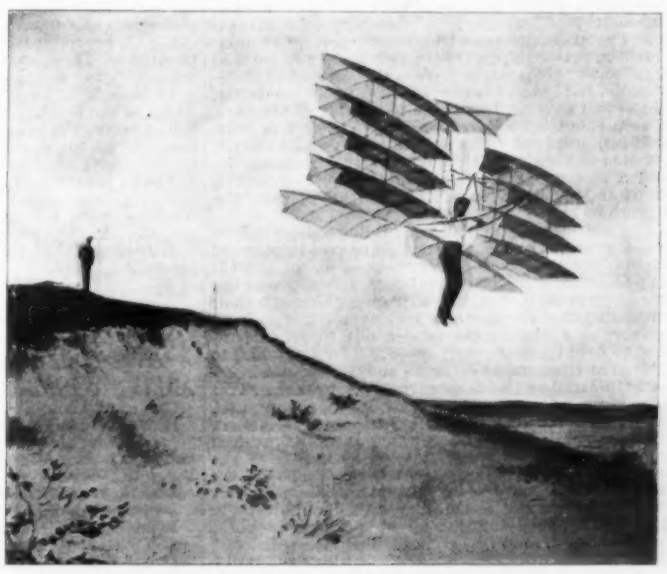


FIG. 7.—MULTIPLE-WING MACHINE IN FLIGHT.
FROM A DRAWING.

tion with a gliding machine, by simply making use of increased air resistance at greater angles of incidence to stop the headway before alighting on the ground.

Lilienthal probably accomplished more toward a practical solution of the general problem of flight than any of the previous experimenters. He was an accomplished engineer and mathematician, an ingenious inventor and a skillful experimenter. The first thing which required to be practically demonstrated was that a man's weight could be safely carried by gliding upon the air, and that he could alight safely. Lilienthal was the first man to produce these results and to

birds. Indeed, it is not so long ago that a distinguished scientist published an article in which he flatly took the ground that an artificial flying machine was impossible, for three reasons: 1. That Nature, with her utmost effort, had failed to produce a flying animal of more than fifty pounds in weight. 2. That the animal machine was far more effective than any that man may hope to make. 3. That the weight of any artificial flying machine could not be less, including fuel and engineer, than 300 or 400 pounds. These assertions have since been modified, but the author still holds that the possible limit of weight cannot be

reduce them to current practice. He made thousands of glides in safety, until the one dismal occasion in August, 1896, when a defect in his apparatus, probably the breaking of a wire, produced the fatal fall that deprived the world of his services and life. It is true that other men had safely descended in parachutes, that Mr. Maxim has made a short flight upon a dynamic machine, and that Mr. Hargrave has ascended a short distance under a team of kites, but Lilienthal was the first to demonstrate by repeated experiments that man could glide upon the air like a bird, and he will hereafter be recognized as the pioneer who indicated a method through which final success may eventually be won.

Continuing, Mr. Chanute said that when all the problems which he had indicated were solved—and it had been shown that many of them were partly if not wholly solved—they would still have to be combined into one harmonious design before a commercial flying machine was produced. It would therefore be conceived that a good deal of experimenting will be required, and that such experiments will be fraught with danger. He had nevertheless advised in his writings, and in an article in the Engineering Magazine for April, 1896, that experiments be carried on preferably with full-sized machines, carrying a man, as the more fruitful and instructive method. This was good advice, but it might prove dangerous for others to follow. He therefore deemed it desirable that he should ascertain himself how much of risk this involved, if made with due care and precaution.

It was not the intention, in these experiments, to seek to invent a flying machine, although that impression may have been conveyed by some of the newspaper notices of them. The intention was mainly to study the seventh problem—the maintenance of the equilibrium—which it was hoped to gain automatically. This it was expected to do by reversing the method of Lilienthal, who moved his bodily weight to bring back the center of gravity under the center of pressure, as fast as the latter shifted from any cause. It had occurred to Mr. Chanute that it might be preferable to provide moving mechanism within the apparatus itself, to shift the surfaces so as to bring back the varying center of pressure over a fixed center of gravity, and that in such case the operator need not move at all, except for the purpose of steering. The results have been exceedingly gratifying.

Two forms of apparatus have been evolved, each equipped with a different device, which are now believed to be materially safer than any heretofore produced. With them several hundred flights have been made, extending over two seasons, without the slightest personal accident.

In December, 1895, Mr. Chanute secured the services of Mr. A. M. Herring, a civil and mechanical engineer, who had for some years been making experiments in aviation, this being the recent name given to attempts to imitate the birds. The first thing done, after some groping with models, was to build a kite, in order to test the stability of the proposed gliding machine. This was called the "ladder kite," from its resemblance to a step ladder in one of its postures, for it was so constructed as to admit of grouping its surfaces in various ways. This kite proved exceedingly stable, flying in gusty winds without the eccentricities common to that class of apparatus. Then the construction of a similar machine was begun, which was capable of carrying a man; but first Mr. Herring rebuilt a machine, previously tested by him in New York, somewhat similar to that of Lilienthal, so that the known should be tested before passing to the unknown. With these two machines Mr. Chanute and Mr. Herring, and two assistants (Mr. Avery and Mr. Butusov), went in June, 1896, to the desert sand dunes at the south end of Lake Michigan, north of Miller Station, about thirty miles from Chicago. The Lilienthal-like machine was the first tested.

Fig. 1 represents Mr. Herring in the Lilienthal type of apparatus, poised in a wind at the top of a sand hill about thirty feet high, preparatory to making a glide. The machine spread 168 square feet of sustaining surface, was equipped with a double rudder and weighed thirty-six pounds. With this about 100 glides were made, the longest being 116 feet. It proved from the outset an awkward machine to handle. Lilienthal, whose skill had been developed by four or five years of practice, obtained valuable and safe results with it, but it was otherwise with novices. Its operation involved a struggle with the wind before it could be brought under control, and this continued after the flight had begun.

In Fig. 2 this machine is shown gliding a short height over the ground. This was practiced to avoid untoward accidents, for the winds experimented in, of 12 to 17 miles per hour, constantly varied the position of the center of pressure so far and so rapidly through their fluctuations, that the operator had to shift his position as actively as a tight rope dancer, but to greater distances, to avoid being overturned. The body had to be moved at times some 15 or 18 inches, and not infrequently in landing the apparatus was broken. This involved less personal risk than might be supposed, because the radiating ribs curve downward, as shown, so that they first come into contact with the ground when an awkward landing is made, and save the operator from harm. Similar experience seems to have obtained with an acrobat in a public garden in Vienna, with Prof. Fitzgerald in Dublin, with Mr. Lamson in Maine, and with the Journal newspaper in New York, although Mr. Pilcher, in England, has succeeded well with a modified Lilienthal apparatus of his own building. At last the machine shown in Figs. 1 and 2, after having been broken and mended a number of times, was finally discarded altogether, and within six weeks thereafter Lilienthal's sad death occurred while experimenting with his double-decked apparatus.

After abandoning this first form of machine, the experimenters in the sand dunes next tested the machine built after the fashion of the ladder kite which had proved so steady in the air.

Fig. 3 exhibits a front view of this arrangement. It consisted of six pairs of wings, superimposed and trussed together, pivoted at their roots upon a central frame, the lower chord of which was spread open to receive the man at the center. Here he was expected only to move for the purpose of steering, the stability to be maintained by the movements of the wings above him, which swung on their pivots back and forth, restrained by rubber springs, when the wind struck one side more than the other, or changed the center of pressure fore and aft. It will be seen that this is just the reverse of the first method tested, in which the man moved and the wings remained fixed. This wing movement took place as expected, but it was very soon found that there was an essential difference between the support from the wind derived from the same arrangement when flown as a kite, at an angle of incidence of 30 to 40 degrees, and when flown as a gliding machine, at an angle with the wind of three or four degrees, which is the most favorable for reducing the total resistance to a minimum. It was found that at very acute angles the moving air was deflected downward by the front wings, so that the support under all the following wings was greatly diminished, and that the apparatus was inefficient when its surface was considered. This had been expected, from prior experiments, and the frame had been designed so that the grouping of the wings could be readily changed. Then began an interesting and instructive evolution. The grouping of the wings was gradually changed, through six permutations, each being guided by gliding flights and by releasing bits of featherdown in front of the machine, and watching the paths of the air currents which swept past the wings. The result of this evolution was to change greatly the outward appearance of the apparatus, while retaining the same general principle.

Fig. 4 shows the improved arrangement as seen from one side in flight. It will be noticed that no less than five of the six pairs of wings have been superimposed at the front and trussed together. That the operator is within and under them, and that a single pair of wings remains at the rear to serve as a tail. This tail was flexible and vibrated up and down in flight when the angle of incidence varied in consequence of the back and forth movements of the pivoted front wings.

Fig. 5 shows a front view of the same machine in flight. About two hundred glides were made, in winds of 13 to 22 miles an hour, on a descending course of about 1 in 4 (14°), the longest flight being 82 feet from a height of about 20 feet. There was, however, undue friction in the wing pivots, thus retarding their automatic action, so that the operator had to move two or three inches, as against some 15 or 18 inches on the previous machine, and there being some further defects in the spacing of the wings, both vertically and horizontally, it was determined to rebuild the machine with the practical information thus obtained.

Camp was accordingly broken up early in July, with the conviction that more had been learned during this two weeks of experiment with full-sized machines than had previously been acquired during about seven years of theoretical study and experiments with models. The equipment was returned to Chicago, where three machines were constructed, and toward the end of August they were taken out to the wilderness of sand dunes north of Dune Park, about five miles from Miller.

Fig. 6 shows the multiple-wing machine as reconstructed. This consisted of the same wings and of a new frame, and instead of ordinary pivots, there were ball bearings at the end of vertical wooden posts to which the roots of the wings were attached, the latter being all trussed together, with vertical posts and diagonal wire ties, this being probably the first application which has been made of the Pratt truss to flying machine design. The frame was all made of spruce, the surfaces were of Japanese silk varnished with pyroxylene; the complete machine weighed 33½ pounds, the supporting surface at the front was 143½ square feet, including a concave aerocurve over the top, added when the front wings were cut down to four pairs, and the rear wings or tail measured 29½ square feet in area. With this arrangement a great many glides were made, with the result of more than doubling the lengths previously attained, of reducing the angle of flight to 1 in 5, or 10° to 11°, and of diminishing the required movements of the operator to one or two inches in preserving the equilibrium.

Fig. 7, reproduced from a drawing, shows this apparatus as it appeared in flight. It might have been preferable to omit the aerocurve over the top, and to have placed all the supporting surface in the pivoted wings at the front. This aerocurve was added to save the expense of rebuilding the old wings, and this saving proved to be a mistake. The wings were so far racked and distorted by their prior service that they did not support alike and did not balance the weight properly, and thus the results obtained with that machine were inferior to those to be hereafter described. Yet the principle is deemed to be sound, and it is believed that the apparatus can be further improved.

(To be continued.)

INTERESTING FACTS AND SUGGESTIONS ABOUT ALASKA.

ALASKA is two and one-half times as large as Texas.
It is eight times as large as all of New England.
It is as large as the South, excluding Texas.
It is as large as all the States east of the Mississippi and north of the Ohio, including Virginia and West Virginia.
It makes San Francisco east of our center.
Its coast line is 26,000 miles.
It has the highest mountain in North America.
It has the only forest-covered glacier in the world.
It has the best yellow cedar in the world.
It has the greatest seal fisheries.
It has the greatest salmon fisheries.
It has cod banks that beat Newfoundland.
It has the largest river in the world.
A man standing on the bank of the Yukon, 150 miles from its mouth, cannot see the other bank.
The Yukon is twenty miles wide 700 miles from its mouth. With its tributaries it is navigable 2,500 miles. It discharges one-third more water than the Mississippi. The water is fresh fifteen miles from its mouth. It has more gold in its basin than any other river.
Yukon basin gold is estimated at $5,000,000,000.
Silk should be worn next to the body, then woolen, and then furs.
Citric acid should be taken to prevent scurvy.
Snow glasses should not be forgotten.
Nowhere are mosquitoes so numerous.
There are two kinds of poisonous flies.
There are no snakes in Alaska.
Moose are plentiful. The flesh resembles horse flesh.
It is probable that in twelve months Dawson will be within four days of Juneau.
In Central and Northern Alaska the ground is frozen to a depth of 200 feet.
Snowfall in the interior is very light—six inches or so.
The heaviest rain and snow are on the southeast coast.
No land contains finer spruce timber.
In its low temperatures gold filling in teeth contracts and falls out. Use amalgam.
Men born in southern latitudes have become insane in the long dark.
Take a chessboard and men. They prevent dementia.
A temperature of 75 degrees below zero has been recorded.
When it gets lower than 50 there is no wind.
A tent is as good as a house and is cheaper.
No shelter is needed except when the wind blows. At other times a sleeping bag answers all purposes.
Just below rapids ice forms only nine feet thick, and there fishing is done. In other places it will reach forty feet.
In the dark season twilight lasts six hours and almost any kind of work can be done.
Elk, cariboo, and grouse are common, and easily killed.
Don't eat snow or ice. Melt them. Else quinsy.
In low temperature the inside of the throat sometimes freezes. This is locally called "frost burning."
For frozen fingers use cold water.
Sweat under blanket in summer or get rheumatism.
In summer all land not mountain is swamp.
Talk on the ice pack is heard a half mile.
An expert placer miner can pan dry.
Alaskan "dust" is as big as wheat.
Some gold is fine enough to float.
Wear silk gloves and then fur.
Reindeer will be the future locomotives.
Alaskan dogs are wonderfully intelligent—the result of selection and heredity.
The natives are all honest.
Hay grows as high as a man's head.
Hardy vegetables can be raised.
All streams show true gold fissures.
Take plenty of flour. Buy all you think you need, then buy more. Last winter a man killed himself because he had five pounds of baking powder and no flour.
Under act of Congress communities of miners can make their own laws.
No thief gets a fairer trial anywhere, or any prompter execution.
Make caches on platforms six feet high. Wolves.
It will pay to wait a year or two. It costs $1,000 now and will cost $200 then.
All distances are gigantic. It is 2,000 miles from Sitka to Klondike.
All wood in the Aleutian Islands grew on glaciers in Alaska.
Whole forests break into the sea.
Some streams are bridged by glaciers.
Some wood is beautifully polished by glacier action.
Avalanches in the interior are unknown.
Owing to dryness, there is not much suffering from the cold.
Take a 40-80 rifle, with telescope sights.
One small tribe makes $2,500 a year from silver fox skins. They are worth $250 each.
Exposed portions of the body freeze in three minutes.
Enough library: One Bible, one Shakespeare.
Snowshoes not needed in the mine country.
Buy mines from discouraged miners.
Trading companies will not carry goods for competitors.
Next year competition will bring down their prices 50 per cent.
Meals on the boat up the river cost $1 each.
Men who have gone to make their living the coming winter sawing wood will not have time to saw much.—The Chicago Times-Herald.

In the brass rolling mills of the C. Kulmiz, at Achenrain, in the Tyrol, there is now working a rolling mill driven by electricity, which has hitherto been considered an extremely difficult problem. Originally this mill received its motive power from the river Ache, when, at times of prolonged cold, scarcity of water frequently interrupted the work, to avoid which 300 horse power was taken from the Ache at a point about 1½ miles above the mills, by means of a turbine made by Messrs. Ganz & Company, of Budapest Leobersdorf. The power is transmitted to the works by means of a polyphase current from a generator capable of giving an output of 160 horse power. At the works the current is received by a pair of polyphase motors by Ganz & Company, of 60 horse power each, operating in conjunction with the turbines of the mills; the excess power of the turbines is made use of for lighting the mill, and also the town of Achenrain, and it is said that, notwithstanding the shocks and suddenly varying loads which must occur in driving a rolling mill, the light remains steady, and altogether the installation is considered a great success.

There seems some prospect of worm gearing coming into favor again where a large reduction ratio is needed, says The Practical Engineer. Such gears have the advantage of being comparatively noiseless; but have, in the past, had an evil reputation for excessive frictional loss. More recent work with accurately made wheels has shown that this loss need not necessarily be very large. Prof. Stodola, of Zurich, has obtained an efficiency of 87 per cent. when using worm gearing to transmit 21 horse power, the worm running at 1,500 revolutions per minute. This worm was 3·15 inches in diameter, the pitch being 3·2 inches, and the wheel, which was of gun metal, had 28 teeth. Similarly, Mr. E. Kolben has also obtained excellent results with worm gearing, while in America the Sprague Company, using the Hindley form of worm, have, it is stated, got remarkably high efficiencies with this class of gearing, which they use for electric lifts.

ENGINEERING NOTES.

Lighthouses in Denmark are supplied with oil, which is pumped on the waves during a storm. This explains the fact that two or three vessels are always to be seen round each lighthouse in rough weather.

A general and international exhibition of carbide of calcium and acetylene and all that relates to them is being organized at Cannstatt (Würtemberg). It will be held in February, and will be the first public exhibition of the kind. All inquiries should be addressed to Messrs. Herm. Weissenburger & Company, Cannstatt.

Of a total length of 2,018 miles of railway in New Zealand, 267 miles in the South Island and 116 miles in the North Island are still laid with 40 pound iron rails, and 67 miles in the South Island with 30 pound iron rails. Most of the renewals last year were made with 53 pound steel rails, only sixty-nine rails of 70 pounds per yard being put in; but the general character of the New Zealand lines, which are of 3½ feet gage, is light, according to our ideas.

During the past few years several articles have been published on the possibility and advisability of welding instead of riveting boiler plates The advantages of employing electric welding have been fairly shown up, but so far as known no boiler maker has used the process in practical work. Two or three shops are, however, experimenting with the process, and hope to find it available for welding on the heads of tubular boilers, though they are not yet ready to make any statement regarding the success of these experiments.

The number of goods wagons in Germany is not by any means adequate, and a number of new ones are being made. The Prussian state railways possess at present 58,000 closed and 162,000 open goods wagons; the Hessian railways have 8,000 closed and 15,000 open goods wagons; in Würtemberg there are 3,029 closed and 3,232 open; and in Bavaria 9,404 closed and 9,753 open goods wagons. In the latter country especially there seems to be a goods wagon famine, and people complain; they often have to wait some eight to fourteen days for wagons.

Water works disinfection on a wholesale plan was tried at Maidstone, England, according to British journals, which state that Dr. Sims Woodhead treated the reservoir and mains of a district of that city with a heavy dose of chloride of lime. About 10 tons of the lime were mixed with 240,000 gallons of water in the reservoir, and the solution allowed to flow into the mains. At a certain hour it was turned into all the house connections of the district, and what did not escape in this way was eventually blown off through hydrants. The disinfection was done to destroy typhoid germs.

The local returns of shipbuilding in 1897, so far as they have appeared, make it quite evident that the record for shipbuilding in Great Britain for that year will be considerably behind that of 1896, which, however, exceeded that of any previous year. Belfast, for example, launched in 1897 some twenty-one vessels, with a tonnage of 108,863, or 10,000 less than the tonnage of the previous year. On the Humber, again, Earle's Shipbuilding Company launched in 1897 only 4,781 tons, against 13,428 tons in the previous year. Many of the leading shipbuilders have been unable to complete their contracts, and some of them have lost as much as five months' work owing to the engineering strike. It will not be surprising if, when the returns for the year are made up, it turns out that 1897 is 250,000 or 300,000 tons behind the previous year.

The British Admiralty authorities are about to complete the great harbor at Dover, which has been the subject of discussion for many years. Enormous sums of money have been expended during the last fifty years upon the underground fortifications at that place, originally designed to protect a harbor which, so far as its value in war times was concerned, never had any existence. For some time the conviction has been growing that these elaborate underground works are useless, as it is not probable that a foreign enemy would select that point for attack. Hitherto the harbor works have been confined to the so-called Admiralty pier, which was begun on a colossal scale, and ends in a worthless fort, which mounts two 80-ton guns, and was built at prodigious expense, owing to the cost of working under water at its foundations. Almost as soon as it was finished it was found to be constructed so badly that an additional sum of no less than £40,000 had to be spent in securing the magazines of the now obsolete guns, which could not be discharged a dozen times without disabling their mountings. Now the harbor is to be completed, so that a safe anchorage and coaling station shall be provided in time of war for a fleet of twenty line-of-battle ships and a corresponding number of smaller craft. The shore batteries will then have something to defend. The colossal work will be begun at once and finished as rapidly as possible.

The work of the Jungfrau Railway is being pushed forward, in spite of the severe winter weather which has now set in, says Industries and Iron. In Lauterbrunnen water power to the extent of 2,400 horse power is now available, and half of this force is being utilized for the electric dynamos employed in the boring of the Eiger Glacier tunnel. The mountain stream has been diverted from its course for a distance of ten kilometers, extending from the water wheel house to the Scheidegg Station and the Eiger Glacier, and the open line between the Scheidegg and the glacier, with a tunnel of 80 meters, is prepared in its main details, so that the electric railway over this tract can be opened in the first half of next June, and in time for the tourist season. The principal tunnel has been carried to a distance of 150 meters by hand boring—mainly the work of Italian excavators—and the preliminaries for tracing out the great tunnel have been accomplished after some two years' labor. The rock is found to be excellently adapted for tunneling, and experiments on the Jungfraujoch have proved that it is reached at a depth of 25 to 30 meters under the snow, instead of 70 meters, as was at first apprehended. The opening trial of the Cornergrat Electric Railway has likewise proved satisfactory. It was made a few days ago, and the line will be opened to passengers in the early spring.

MISCELLANEOUS NOTES.

Through the gift of Mrs. Charles Pratt, the Pratt Institute, of Brooklyn, N. Y., has come into possession of 1,000 examples of textiles, ranging over several centuries of European and Oriental manufacture. The collection was purchased from Signor Salvador, of Florence, Italy, by whom it was collected, and it is said cannot be duplicated.

One of the uses for which balloons may be employed is the investigation of the sea bottom. It has been found by aeronants that frequently the bottom is clearly visible from a balloon through the water. This fact has recently been made use of to recover a torpedo boat which had been lost off Toulon. Not only was this found, but also two others, which had vanished at an earlier date.—Prometheus.

It appears that the British government is actually using American writing paper, says The New York Sun. All the departments use typewriting paper made in the United States. Her Majesty's stationery office, which supplies all the departments, allows common sense to take precedence over patriotism. The India Office, which is the most exclusive and old fashioned of them all, grumbled upon making the shocking discovery, but one of the chiefs of the stationery department answered: "What's all this fuss about? If we can get note paper in America better and cheaper than the British manufacturers can supply, we will place our orders there."

At seven o'clock in summer and at eight in winter a message is flashed by the telegraph from Berlin to over ten thousand places in the German empire, says The Nautical Magazine. Every line is cleared that this message may have free course. The message is as follows: h. b. l. n. g. m. m. r., which means "Hier Berlin, guten morgen, monsieur" ("Here Berlin, good morning, sir"); and instantaneously Berlin receives in reply h. h. b. g. g. m. m. r. ("Here Hamburg [or another town], good morning, sir"). And then the business of the day begins. This daily ceremony gives the time to the German empire, the watches and clocks of which indicate middle European time.

An artificial stone now being made at Woking, England, by the Owen process, consists of 87½ per cent. of quartzose sand and 12½ of lime, which first being sifted and mixed, are subjected for thirty-five hours to a hydrostatic pressure of 60 pounds to the square inch. A distinctive feature of the process is the boiling of the water used before it is pumped into the pressure chamber, the driving out of all air in this way being claimed to obviate blowholes and similar defects in the stone. The product improves with exposure to the atmosphere, being capable in a month of standing a pressure of 4,000 pounds to the square inch. It is cast to any desired form in steel moulds. Pieces of the material have been repeatedly subjected to sudden cooling from a high temperature and to freezing—while saturated with water—and sudden thawing, without any signs of disintegration.

Kaolin and china clay are terms often employed in technical publications as if they were interchangeable, says The Engineering and Mining Journal. Kaolin is mineralogically a simple hydrous silicate of aluminum, which is indeed practically the composition of china clay. Kaolin is seldom found pure, and it is usually necessary to subject it to some kind of mechanical treatment to free it from the impurities which would be objectionable in pottery making, for which purpose by far the greater part of the production is employed. In the principal American deposits the yield of the clean material is only about 33 per cent. of that which is dug. In the industry the term kaolin is used to designate the crude material, while the finished product is referred to as china clay. This use of the term may not be justified mineralogically or linguistically; but since it has become established in the trade it is better to refer to the finished product as "china clay," and not as "kaolin," which, of course, leads to more or less confusion.

A curious relic of the old days of the paper duties which so much hampered journalistic enterprise in the first half of the present century will shortly come up for sale at a London auction room, says The Westminster Gazette. It is the first number of "Berthold's Political Handkerchief," being a news sheet printed on cotton fabric instead of paper, the idea being to evade the paper duty. It is dated London, Saturday, September 3, 1831, price 4 pence, and the letterpress, which is fairly legible, is as remarkable as the material on which it is printed. The tone of this news rag is intensely radical, but it reproduces the order of ceremonial to be observed at the coronation of King William IV and Queen Adelaide on the following Thursday, and it is announced that a proclamation to the people of Europe will appear in our "next cotton." It is embellished with a medallion woodcut of Napoleon crossing the Alps, but the ink in this pictorial effort was too much for the cotton, and the Alps are in a fog and the emperor on horseback very indistinct.

Librarian Young has forwarded to Congress his annual report on the Congressional Library, the first ever made. In addition to speaking in a very commendatory manner of Mr. A. R. Spofford, for many years the librarian, the report advocates a circulating library, and earnestly recommends that the library be opened at once for night readers. The amount of copyright fees for the year beginning July 1, 1896, was $55,376, the amount for May and June last being estimated at $9,100. Expenses of the library were $61,604.26. Of this sum, $54,620.47 was for salaries, $5,980.02 for the purchase of books, and $11,003.77 for contingent expenses. The library, as transferred, contained 787,715 volumes of books and 218,340 pamphlets. Both these figures are estimated. On November 1 the number of books in the hands of readers was 3,320, of which 1,446 were charged to Senators and members no longer in Congress and to others entitled to take out books. Most of the 1,446 books are regarded as lost. They were given out during a period covering thirty years. The daily average of books in the hands of readers is placed at 3,000. The percentage of books lost in the last thirty years is about five in each thousand. It was impossible, the librarian says, to give an exact count of the books, because of the haste to have the library ready for use at the opening of Congress.

SELECTED FORMULÆ.

To Prevent Rusting of Iron.—A patented process to prevent rusting of wrought or cast iron consists in applying with a brush a strong solution of potassium dichromate and drying in a stove or over an open fire. Drying at ordinary temperature is not sufficient. To ascertain if the heat is strong enough, the iron is moistened with a little water. So long as this takes up any color the heat must be increased. When the proper degree of heat is reached, a fine deep black layer results, which is not acted upon by water, and protects the surface from the action of the atmosphere.—Ph. Woch.

Toning Bath for Solio Paper.—The following directions are given by The Photographic Times: Print in direct sunlight, covering thin negatives with tissue paper, allowing the print to get a little darker tint than the finished print should be. Place print without previous washing into the following:

COMBINED TONING AND FIXING BATH.

To tone thirty cabinets take—

Stock solution A	8 ounces.
Stock solution B	1 "

STOCK SOLUTION A.

Sodium hyposulphite	8 ounces.
Common alum	6 "
Water	80 "

When dissolved add 2 ounces of borax dissolved in 8 ounces hot water. Let stand over night and decant clear liquid.

Chloride of gold	15 grains.

When dissolved add 2 ounces of borax dissolved in 8 ounces hot water. Let stand over night and decant clear liquid.

STOCK SOLUTION B.

Chloride of gold	15 grains.
Lead acetate	64 "
Water	8 ounces.

Tone to desired color and immerse prints for five minutes in the following salt solution to stop the toning:

Salt	4 ounces.
Water	32 "

Wash one hour in running water or in sixteen changes of cold water, when prints may be mounted same as albumen prints. The following hints are suggested: All solutions should be used as cold as possible. In warm weather prints should not stand over night before mounting. Mounted prints must be thoroughly dry before burnishing.

Mouldable Mass.—For luting vessels made of glass, porcelain, etc., which are to be used to hold strong acids, a mixture of asbestos powder, water glass and an indifferent powder (permanent white, sand, etc.) is recommended. Experiments which have been made in this direction have confirmed the reliability of the assertion. To begin with, asbestos powder was made into a pulp with three or four times the quantity (weight) of a solution of soda water glass (of 30° Baumé). The same is exceedingly fat and plastic, but is not very well suited for working, as it shrinks too much and cracks when drying. By an addition of fine writing sand of the same weight as the asbestos used, the mass can be made less fat, so as to obviate shrinking, without detracting from the plasticity. Small vessels were moulded from it and dried in the air, to be tested afterward. Put in water, the hardened mass becomes soft again and falls apart. Brought into contact, however, with very strong mineral acids, it becomes even firmer and withstands the liquid perfectly. Concentrated nitric acid was kept in such small vessels without the mass being visibly attacked or any thing penetrating it. The action of the acid manifestly has the effect that silicic acid is set free from the water glass in excess, which clogs up the pores entirely and contributes to the intation. Later on, the mass cannot be dissolved by pure water any more. Another experiment showed that the mass is also highly fireproof. One of the moulded bodies was kept glowing in a Bunsen gas flame for about half a day after treatment with acid, without slagging in the least. For many purposes it ought to be welcome to have such a mass at hand. It cannot be kept ready for use, however, as it hardens a few hours after being prepared; if potash water glass is used instead of the soda composition, this induration takes place still more quickly.—Painter's Magazine.

Deodorant for Water Closets.—

Ferric chloride	4 parts.
Zinc chloride	5 "
Aluminum chloride	5 "
Calcium chloride	4 "
Magnesium chloride	3 "
Water, sufficient to make	90 "

Dissolve, and add to each gallon 10 grains thymol and ¼ ounce oil of rosemary, previously dissolved in about 6 quarts of alcohol, and filter.

Valuation of Insect Powder.—The value of insect powder is in direct proportion to the combined amount of essential oil and soft acid resin present, and in inverse proportion to the amount of chlorophyl. The powder should yield 5·25 per cent. of combined essential oil and soft resin; chlorophyl should be absent or present in the merest trace. Place 100 grains of the powder to be tested in the cylinder of a glass syringe (1 ounce). The powder should be pressed down compactly onto a piece of absorbent cotton, to act as a filter. Moisten with ether 0·735. Close the top of the syringe, and macerate for thirty minutes; percolation may then proceed; the powder being repercolated with the same fluid four times, and finally washed through with sufficient ether to make up one fluid ounce. The resulting percolate should be of a rich, yellow color; if a pronounced green color be the result, the sample may be discarded at once. In the absence of much green coloring matter, the fluid may be carefully evaporated (temperature not exceeding 200° F.), and the residue weighed in a tared watch glass. The resulting soft mass should not weigh less than 3·75 grains, and in the finest samples reaches 5·5 grains, and should have the flower's odor.—Phar. Jour.

PETROLEUM SOLIDIFICATION.*

THE paper comprised a critical examination of patent literature on the subject, and subsequent experiments made with known and suggestive processes, the object being to make compounds containing 90 per cent. of liquid petroleum. Substantially the methods may be divided into three: (1) Solidification by means of soap, (2) with vegetable saponifiers, and (3) other agents, such as gelatine. In the first series Dr. Rideal used stearic, oleic and elaidic acids, the first giving the best results. A better product is obtained by forming the soap in contact with the petroleum than by adding soap ready made. If we take, say, 9 ounces of ordinary burning oil, add to it 1 ounce of stearic acid, heat on a water bath, add enough aqueous soda to neutralize, and agitate with an egg whisk, we get by and by a granular, opaque, white, firm mass. With sodium silicate, instead of aqueous soda, a pure white, pearly, hard mass is the result, and we obtain a hard, white, translucent mass when sodium aluminate is used. These are the best results. Oleic acid affords products in the nature of jellies. Elaidic acid is a failure. "Dry soap" alone, with water, gives a compact mass, and beeswax, with dry soda, ammonia or sodium silicate, gives substances of the consistency of vaseline. Of the oils, cocoanut and castor give the best results when saponified with aqueous soda in the presence of the petroleum. Castor oil in this way affords a hard, firm, cream-colored mass, and the cocoa nut oil product is even harder. Generally speaking, the glycerine liberated when oils are used tends to soften the mass; that is why the fatty acids are preferable. Aqueous potash was also tried with oils and acids, but it is not, on the whole, so good as aqueous soda. Resin soaps were a failure.

All these processes for the utilization of various soaps in order to solidify petroleum are probably covered by the existing patents, especially those of Lawson (Eng. Pat. No. 2971, 1888) and of Smith and Pearson (Eng. Pat. No. 3044, 1889). At the same time no one has drawn attention to the modifying action of the glycerine if allowed to be present in the finished product. Saponification by means of silicate of soda is covered by Lawson in his patent, but the use of sodium aluminate appears to be novel. Sodium aluminate appears to be superior to sodium silicate with many oils. It is a much more efficacious agent, for example, with both tallow and olive oil, as it renders these oils available for solidifying petroleum, which could not be effected under the same conditions with water glass. A patent dating so far back as 1883, by S. M. Eiseman (No. 3972), apparently covers all methods of making soaps in conjunction with paraffin, either by the action of alkali on fatty acids or by the unsaponified fats and oils. This patentee has also devised a method of protecting the granulated petroleum from atmospheric influences and the action of a moderate temperature by coating the product with a mixture of calcium or magnesium salts and sodium silicate. He draws attention to the hardness of the products obtained with castor oil, and thus confirms what one would conjecture from a knowledge of the soaps made therefrom.

Some interesting products can be obtained by the blending of a soap-solidified petroleum with petroleum jelly. When equal quantities of vaseline and petroleum jelly are heated together and 10 per cent. of oleic acid and the requisite quantity of dry soda added, a jellylike and yellow product is obtained which resembles ordinary vaseline in appearance, but is of softer consistency and smells of petroleum. When stearic acid is substituted for the oleic acid, a pale yellow translucent jelly is obtained with dry soda and a pale yellow opaque jelly when aqueous soda is employed. These admixtures may be found useful as lubricating mediums, and seem to indicate that useful products could be similarly made from a petroleum from which the lighter spirit only had been removed.

The use of quillaia bark is covered by two patents (Grave, No. 13,673, 1888, and Stringfellow, No. 14,832, 1890); but Dr. Rideal's experiments with it show that the products are not equal in hardness or consistency to those obtained by the use of soap. The best results were arrived at by adding 5 per cent. of the ground bark to the petroleum, then 5 per cent. of water and agitating, when a white opaque jelly resulted. Gelatine, albumen, casein and Ghattí gum (with ferric chloride) were tried and with indifferent results.

In addition to the use of solidified petroleum as a detergent, there is an outlet for it as an illuminating and heating agent, and as a lubricant. To these points Dr. Rideal called attention.

The yearly report of United States Fish Commissioner John J. Brice shows that 180,000,000 of cod-fish eggs were collected, from which 98,000,000 of cod fry were liberated on the natural spawning grounds along the coast of Massachusetts. This was an excess over the previous year of about 40,000,000. Of winter flounders the output was over 64,000,000 of fry from about 80,000,000 of spawn. The work of propagating lobsters has been largely extended, and, although there was a poor catch of females with eggs, over 128,000,000 of spawn was secured, from which were produced 115,000,000 of fry, an increase of 30,000,000 over the output of the previous year. Of shad spawn over 203,000,000 were secured, some 55,000,000 more than during the previous year. Of whitefish the take of eggs was 200,000,000; of lake trout, 16,000,000; of Atlantic salmon, 2,800,000; of landlocked salmon, 1,000,000; of quinnat salmon, 75,000,000, and the season for these had not ended when the report was compiled. To test the probable value of the quinnat salmon in Eastern waters, 4,000,000 of fry were liberated last spring in the St. Lawrence, Hudson and Delaware Rivers in New York and in the Indian and Penobscot Rivers in Maine, and 250,000 were held to be liberated when yearlings in the Penobscot.

On October 1 last there were 2,186 steam engines, with a total horse power of 149,096, employed in Prussia, solely in connection with electricity plants; and there were 651 engines, with a total horse power of 42,839, which were not solely devoted to electricity.

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*By Samuel Rideal, D.Sc., Lecturer on Chemistry at St. George's Hospital.—Abstract in Chem. and Drug.

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